MURBY'S "SCIENCE AND ART DEPARTMENT" SERIES OF TEXT-BOOKS.

EDITED BY SYDNEY B. J. SKERTCHLY, F.G.S.

"BE SURE THAT WISDOM LIES
IN EVERY LEAF AND BLOOM."

BOTANY:

STRUCTURAL AND PHYSIOLOGICAL.

BY

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PREFACE.

The aim of this work is to provide teachers, students in science classes, and private workers, with an elementary manual which shall be trustworthy as to facts and consecutive in construction. It is essentially a *working manual*, placing before the student the more important phenomena of vegetable anatomy and physiology, and instructing him as to the best and most accessible illustrations of the subject. Common wild or garden plants supply most of these examples, and it may be as well to observe that most of the facts described have been matters of observation with the author, and the work is not, therefore, to be regarded as a compilation, but as an independent treatise.

In some few cases the author has supplied matter which is not, to his knowledge, given in existing manuals, but which he regards, nevertheless, as being essential to even an introductory text-book. The following are the most important of these points:—

1. The description of the receptacle and flowering organs of the *columbine*, and the mode of illustrating the arrangement of the parts. It would be advisable for the teacher to prepare similar diagrams of other flowers.

2. The structure of bark is worked out afresh, the *ash* being chosen as the example.

3. The articles on the cause of *eyes, burrs,* and *colour* of woods are original.

4. Also the remarks on the deliquescence of woody tissue.

Hints to Teachers.—It is, of course, essential for the teacher to be practically acquainted with the subject, and to

assist in obtaining this knowledge, the following hints are offered:—

Tissues.—*Cellular.*—To show the structure of tissues, a moderately good microscope is required—such, for instance, as may be obtained of any good maker for about three guineas.

Cell-structure and development can be readily studied among the *confervæ*, which abound in stagnant pools and marshes. In the neighbourhoods of Barking and Woolwich we have gathered many species. The common *conferva*, or *water-flannel*, shows cell development by fissuration. In *hydrodictyon*, found in the same localities, the cells contain gelatinous matter, which divides and gives rise to new cells.

Desmids, *micrasterias*, &c., furnish examples of unicellular plants reproduced by septation. Other cellular conditions may be studied in the spring in the golden *rust* on rose-leaves, and in autumn in the black *rust* on brambles. The leaves of *sphagnum*, or *bog-moss*, show fibro-cellular tissue, and may be gathered all the year round. The stems of *rushes* show, in cross-sections, stellate cells and lacunæ. Sections of *date-stones* and *vegetable ivory* afford good examples of sclerogen-cells.

Vascular.—Spiral vessels may be obtained from the petiole of *rhubarb*, which must, however, be first boiled; or they may be procured, in a fresh condition, from the petiole of *strawberry*, by slightly incising it transversely, and gently pulling the portions asunder. Articulated bothrenchyma is to be found in the vagina of the *common reed;* continuous bothrenchyma in soft woods, such as *poplar;* woody fibre in the compact part of *oak*, or in liber; scalariform tissue in the stipes of *bracken;* laticiferous tissue in the under cuticle of *celandine.* Raphides (crystals in cells) may be seen in the leaves and stem of *fuchsia*, *evening-primrose*, and *willow;* also in the root of *rhubarb.*

Cuticles.—The cuticles of many plants may be readily obtained by merely incising the leaves with a sharp knife, and then peeling the cuticle off. When they are thick, the leaves must be first macerated in water or dilute acid; of this character are the leaves of *holly*, *ivy*, *aloe*, &c. Advantage may also be taken of any succulent plants destroyed by frost, the cuticles being easily separated when in that condition. The cuticle of

gasteria possesses thick-walled cells, which show the division between adjacent cells very plainly.

Stomata.—The leaves of the common *flag* will furnish cuticles showing regularly arranged stomata, equally distributed on both sides of the leaf. *Begonia fuchsioides* shows stomata on the lower side only, and occurring in clusters.

Hairs.—Hairs of a uniform character, consisting of about seven cells each, are found on the *tobacco* plant, and the author believes that the structure of these hairs, together with the form and arrangement of the stomata, constitutes a microscopic distinction separating tobacco from every other plant. Cruciform hairs may be obtained from the *rock arabis* of the gardens; stellate hairs from the under-side of the leaf of the *wayfaring tree*; deciduous ditto from the stem and petiole of *ivy*; silicious ditto from *deutzia scabra*; simple hairs from *forget-me-not*; and branched hairs from *verbascum thapsus.*

Glands.—Glands may be found on the leaves, stems, and petioles of many wild *geraniums.* They may be seen lying in cavities on the leaves of *sage,* and glands of a stipulary nature occur at the base of the petiole of the *balsam poplar.*

The examples given in the work will readily afford specimens of the various organs treated of, but it may be as well to mention that the *Canterbury-bell* presents a fine opportunity of studying pollen-tubes. If the pollen be brushed from the stigma after it has lain there for a few hours on a hot day, the young tube will be seen protruding from the grain, and on the second and third days the tubes may be traced throughout the style when a transverse section of the latter is placed under the microscope.

The table of economic products will be found useful. It was prepared by Mr. R. W. Skertchly.

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INTRODUCTION.

BOTANY[1] is the science which treats of plants, and is one section of *Biology*,[2] or the science of life; *Zoology*,[3] or the science of animals, being the other section.

Divisions.—We may study plants in four different ways, namely:—

1. We may study all that relates to the *form* of plant structures, for which it is not necessary that the specimen to be examined should be alive. This is called *Morphology*.[4]

2. We may study the *living* plant and observe the action of its various parts. This is *Physiology*.[5]

3. We may consider plants in a geographical sense, and compare those of one area with those living in another. This is *Distribution*.

4. We may examine into the causes which produced plants in the first instance, and permitted of the formation of so many varieties. This is *Ætiology*.[6]

1. **Morphology** may itself be divided into three sections, *anatomy*,[7] *development*, and *taxonomy*.[8] Anatomy treats of the structure of the organs and tissues, both with regard to their external form, and to their internal structure. The microscopic examination of parts of a plant is called *histology*,[9] which is,

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[1] Gr., *botane*, a herb. [2] Gr., *bios*, life, and *logos*, a discourse. [3] Gr., *zoön*, an animal, and *logos*. [4] Gr., *morphe*, form, and *logos*. [5] Gr., *physis*, nature, and *logos*. [6] Gr., *aition*, a cause. [7] Gr., *ana*, up, and *temno*, to cut. [8] Gr., *taxis*, arrangement, and *gnonai*, to know. [9] Gr., histos, texture, and *logos*.

therefore, a branch of anatomy. General anatomy may be studied with no other aid than that of a knife, for cutting into, or dissecting[1] the plant; whereas histology requires the aid of a microscope also to show what is the minute structure of the plant.

If we trace the history of a plant from the earliest stages to maturity and death, we find certain changes taking place in the different organs. Thus the young plant consists first of a slender stem with a few leaves. As it grows in size not only are other leaves produced, but hard, tough tissues are formed to give strength to certain parts. Then the flower buds appear, the flower opens, the seeds are formed, and the flower and sometimes the plant also dies away. The study of these changes is called *development.*

Again we may compare the forms of different plants, and learn what are their resemblances and differences, and so be able to group together those which possess certain peculiarities in common. This is called *taxonomy*, or *systematic botany*.

2. **Physiology.**—All the parts of a plant have certain actions to perform, and these actions we term *functions*.[2] Any part of a plant designed to perform special functions is termed an *organ*. Thus the leaves are organs, their functions being to absorb certain matters from the air, and to throw off certain others from the plant itself.

All the functions of a plant fall under one of two classes, they either help to support the existence of the individual plant, in which case they are called *sustentative functions*, or they serve to continue the race by the formation of new individuals; these are called *reproductive functions*.

3. **Distribution.**—If we consider the area over which

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[1] L., *dissectus*, cut asunder.
[2] L., *fungo*, *functus*, to perform.

certain plants range, and the plants of different areas, we may call such a study the *geographical distribution* of plants.

We may also study their distribution in altitude above the sea-level, for we know that species inhabit the mountains which are unknown on the plains, and so on, or we may consider the distribution in depth beneath the sea-level at which sea-weeds are found. These studies are called *bathymetrical*[1] distribution.

Besides these there is the *geological* distribution of plants, that is, the study of the distribution of plant remains imbedded in the rocks.

4. **Ætiology** confines itself to the study of the causes of the varieties of plants, and seeks to discover the mode in which life originated.

Conclusion.—All that is known about plants will come under one or other of the above divisions. In this work we shall confine our attention to the first two divisions, Morphology and Physiology, omitting Taxonomy, however, as a subject which would require a separate volume to treat it in anything like an adequate manner.

CHAPTER I.

CHEMICAL CONSTITUTION OF PLANTS.

Elements.—There are certain substances called *elements* which have never been decomposed, that is to say, no process we have ever been able to apply to them has shown that they consist of anything but that one substance. Gold is an instance of an element. We may melt it, or treat it in any way we please, but we

[1] *Gr., bathos*, depth ; and *metron*, a measure.

cannot change it *without adding something to it.* Sugar, on the other hand, is not an element but a compound body, and we can break it up into three elements of which it is composed.

There are sixty-four elements at present known, and from these all existing bodies are formed, whether solid, liquid or gaseous, whether mineral, vegetable, or animal. But only eighteen of these enter into the composition of plants. They are:—

Carbon, C.	**Silicon, Si.**
Hydrogen, H.	**Potassium, K.**
Oxygen, O.	**Sodium, Na.**
Nitrogen, N.	**Calcium, Ca.**
Chlorine, Cl.	**Magnesium, Mg.**
Iodine, I.	**Aluminium, Al.**
Bromine, Br	**Iron, Fe.**
Sulphur, S.	**Manganese, Mn.**
Phosphorus, P.	**Copper, Cu.**

The letters which follow the names are called *symbols*, and are used by chemists instead of writing the whole word; *C* being put instead of carbon, *H* instead of hydrogen, and so on.

Of these elements the first four—*carbon, hydrogen, oxygen, and nitrogen*—are always found wherever organic matter, whether animal or vegetable, exists; they are, therefore, called *organogens. Sulphur* and *phosphorus* follow next in abundance, and from the frequency of their occurrence have been called *pseud*[1]-*organogens. Silicon* is found in most plants, and gives strength to the stems of grasses, &c. If a plant of *equisetum*, or horse-tail, be carefully soaked in acid, the soft parts will be dissolved away; the form of the plant being left in silica. *Chlorine, iodine*, and *bromine*, are found in plants growing on the coast, and in sea-weeds. The other elements occur in combination in the tissues and juices of plants.

[1] L., *pseudo*, false.

Organic Compounds.—The elements do not occur in their simple state in plants, but are combined into substances, such as starch and sugar, which are called *proximate principles.* These substances consist for the most part of compounds in varying proportions, chiefly of the organic elements C, H, O, N. They may be conveniently divided into *carbonaceous* and *nitrogenous* compounds, the former containing C, H, and O, the latter containing N in addition. The characters presented by these organic compounds are generally such as can be found nowhere but in living tissue, and can be rarely produced in the laboratory. It will also be noticed that many of them, differing widely in their physical characters, such as sugar, gum, and starch, contain the same elements in the same proportion, the differences being accounted for by different arrangements of the molecules.

Carbonaceous Compounds.—Many of these compounds possess hydrogen and oxygen in precisely the same proportion as they exist in water (H^2O),* but it is very improbable that the molecules are arranged in the same way. No more striking example, perhaps, can be adduced of the difference which the arrangement of molecules makes than the fact that sugar, gum, starch, and woody fibre, all contain the same elements in the same proportion, and it is the difference of arrangement alone that gives the different characters to those substances.

The chief carbonaceous compounds are :—

1. Sugar.	**4. Cellulose.**	**7. Caoutchouc.**
2. Dextrine.	**5. Organic Acids.**	**8. Wax.**
3. Starch.	**6. Camphor.**	**9. Resin.**

* The figure [2] following the symbol H does not mean there is twice as much H as O. All the elements combine in certain proportions, and the symbol signifies one *combining proportion* of the element. Oxygen combines with hydrogen in the proportion of 16 : 1. H^2O, therefore, signifies two parts of H to sixteen of O.

1. SUGAR (C^{12} H^{22} O^{11}).—Sugar is found in the juices of many plants. It has a density of 1·6; dissolves in one-third of its weight of cold, and in still less hot water; is insoluble in ether and cold alcohol, and melts at 160° F.

Its more important varieties are: *Cane-sugar*, found in the sugar-cane, beet, maple, &c. It is unfermentable. *Grape-sugar, glucose*, or *dextrose* (C^6 H^{12} O^6) is a fermentable sugar found in fruits. It can be produced from grape-sugar, starch, or woody fibre by treating them with a dilute mineral acid, as sulphuric acid. *Lævulose* occurs with dextrose in fruits, and can only be separated from it by alcohol. It has the same chemical composition as dextrose. *Mannite* (C^6 H^{14} O^6) is an unfermentable sugar found in fungi, sea-weeds, and other plants.

2. DEXTRINE (C^6 H^{10} O^5) is a neutral and insipid body, used in an impure state as British gum.[1] It can be obtained by heating starch to about 160°. It is soluble in water but not in ether or alcohol. The chief varieties of the dextrine group are: *Gum arabic*, or tree gum; *lichenine*, obtained by boiling Iceland moss or lichens in water; *inuline*, prepared from dahlia roots, artichoke, and some few other plants.

3. STARCH (C^6 H^{10} O^5) is very commonly found in vegetables, occurring as granules having distinct shape and markings according to the plant from which it is obtained. The starch from different plants can thus be readily distinguished under the microscope. It is found in the cellular portions of most plants, but is generally prepared from potatoes or rice. It is not soluble in water, but when heated to about 80° F. with water the granules swell up and burst, forming a paste. It forms a blue compound with iodine,

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[1] The adhesive material of postage stamps is dextrine.

and so delicate is this test that very minute quantities can be detected by the addition of solution of iodine in alcohol.

By the action of heat, or of weak boiling sulphuric acid, it is converted into dextrine and glucose, which, as we have said, are soluble. This process takes place naturally in plants during the germination of the seed, and at the time of flowering. It is also induced artificially in making malt.

4. CELLULOSE ($C^6 H^{10} O^5$) is a highly insoluble compound, which is of more general occurrence than any other substance, forming as it does the elementary tissue of all plants. The elastic membrane of cell-walls is formed of cellulose. It is soluble in strong sulphuric acid, and turns yellow on the application of iodine.

Sulphuric acid converts it into a substance closely resembling starch, and having the same peculiarities. By a longer action of the acid a substance very much like dextrine is formed, and when this is boiled with weak sulphuric acid it is converted into dextrose.

Lignine is a variety of cellulose found deposited on it in the woody fibres of plants.

5. ORGANIC ACIDS exist in the vegetable juices of plants. There is a great variety of them, the most important being:—

Acetic Acid ($C^2 H^4 O$), found in conformation with potassium. Vinegar is an impure form of acetic acid.

Citric Acid ($C^6 H^8 O^7$), found in the orange, lemon, tamarind, &c.

Malic Acid ($C^4 H^4 O^5$), found in the apple, gooseberry, &c.

Tannic Acid ($C^{27} H^{22} O^{17}$), found in oak and other barks.

Tartaric Acid ($C^4 H^6 O^0$), found in many plants, but chiefly obtained from the grape.

6. CAMPHOR (C^{10} H^{16} O), obtained from the laurel, but present in other plants.

7. CAOUTCHOUC, or india-rubber, is found in many plants, and is chiefly obtained from figs and euphorbias.

8. WAX, found in stems and fruits. It is soluble in ether, and insoluble in water.

9. RESINS are substances differing from gums in containing very little oxygen. Unlike gums, they are insoluble in water, but soluble in alcohol. When liquid they are called *balsams*. The best known solid resin is *copal*.

Nitrogenous Compounds, or such as contain nitrogen in addition to other organogens. The principal are :—

1. Fibrine.	**3. Albumen.**	**5. Alkaloids.**
2. Caseine.	**4. Diastase.**	**6. Chlorophyll.**

1. FIBRINE, a grey elastic substance, which may be obtained by washing dough in water. It is found in cereals and other plants.

2. CASEINE is very similar to albumen. It constitutes from 20 to 24 per cent. of peas and beans, and in the animal kingdom occurs in milk, and forms the chief constituent of cheese.

3. ALBUMEN is familiarly known as the white of eggs. It is found in the juice of many plants. The so-called albumen of seeds is a substance composed of various materials, and not necessarily of albumen alone.

4. DIASTASE is a peculiar substance formed during the germination of seeds from albumen. It has the property of converting starch into glucose.

5. ALKALOIDS are substances which generally afford the medicinal properties of plants. They are very numerous, but the chief are :—

Atropine (C^{17} H^{38} O^3 N), found in belladonna.

Morphine (C^{17} H^{19} N O^3), found in the juices of plants, is the active principle of opium.

Piperine (C^{34} H^{38} O^6 N^2), found in pepper.

Quinine, or *Chinine* (C^{20} H^{24} N^2 O^2), a most valuable *alkaloid found* in cinchona bark.

6. CHLOROPHYLL[1].—A waxy substance which gives the green colour to plants. It is developed only under the influence of light.

Résumé—

ELEMENTS.

Organogens	Carbon. Hydrogen. Oxygen. Nitrogen.
Pseud-organogens	Sulphur. Phosphorus.
Inorganic	Chlorine. Iodine. Bromine. Silicon. Potassium. Sodium. Calcium. Magnesium. Aluminium. Iron. Manganese. Copper.

PROXIMATE PRINCIPLES.

Carbonaceous Compounds	SUGAR	Cane Sugar. Grape Sugar. Lævulose. Mannite.
	DEXTRINE	Gum Arabic. Licheniue. Inuline.
	STARCH	
	CELLULOSE	Lignine.
	ORGANIC ACIDS	Acetic Acid. Citric " Malic " Tannic " Tartaric "
	CAMPHOR	
	CAOUTCHOUC	
	WAX	
	RESIN	
Nitrogenous Compounds	FIBRINE	
	CASEINE	
	ALBUMEN	
	DIASTASE	
	ALKALOIDS	Atropine. Morphine. Piperine. Quinine.
	CHLOROPHYLL	

[1] *Gr., chloros,* green; and phyllon, a leaf.

CHAPTER II.

WHAT IS A PLANT?

We may endeavour to answer this question in two ways—either by describing how it may be distinguished from minerals and animals, or by taking some plant as a type, and briefly examining its structure and life. The first will give us the *distinguishing* characters; the second, the *general* characters of a plant.

How distinguished.—The mineral, vegetable, and animal kingdoms at first sight appear to be widely separated. No one would mistake the sheep for the grass upon which it feeds, nor the grass for the soil that nourishes it. The sheep is animal, the grass vegetable, and the soil mineral. Nevertheless sheep, grass, and soil are for the most part composed of the same materials. The soil supplies food to the grass, and the grass to the sheep; in other words, the soil is by a certain process converted into grass, and the grass into sheep.

Why, then, cannot the sheep at once derive sustenance from the soil? The answer embodies one of the distinctive features between animal and vegetable life. *Animals cannot derive their sustenance directly from the mineral kingdom, but the mineral matter must be converted into living tissue before it can be assimilated*[1] *into the animal frame.*

Here, then, is a distinction between the animal and vegetable worlds, which may be expressed by saying that *plants alone possess the power of converting mineral matter into living matter.* This is, perhaps, absolutely true; it does not follow, however, that *all* plants

[1] L., *ad*, to, and *similis*, like; to convert into, or make like.

can convert mineral into living matter. One order, the fungi,[1] can only be nourished by living tissue.

Several other distinctions have been advanced, but they are all open to objection, in consequence of the numerous important exceptions that exist.

How living is distinguished from mineral matter.—There is a substance, and a most important one, which is present in every living body, and is never found in the mineral world. This substance is *protein.*[2] It is composed of the organogens carbon, hydrogen, oxygen, and nitrogen, with nearly always traces of sulphur and phosphorus. The precise quantity of each element is uncertain.

Here, then, is the distinction—*no mineral matter ever contains protein, all living matter is full of it.* It is the power of forming protein from the mineral kingdom which forms the distinctive feature between animals and plants. However difficult it may be to determine whether a living body actually does possess this property, this is the only distinction that can be relied upon.

The grass makes protein from the soil. The sheep requires protein to nourish its frame. It cannot make it, therefore it is compelled to obtain it ready-made; and hence it takes grass into its stomach, and the protein of the plant passes into the sheep, and grass becomes mutton. When we use the sheep for food, it is because we need protein. Mutton is then converted into man.

So long as life lasts, protein exists. But when death takes place, decomposition speedily sets in, and the complex protein is resolved into simpler forms, and the elements return to the mineral world until vege-

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[1] Mushrooms, toadstools, and the like.

[2] Gr., *protos*, first; from being the first state of living matter.

table life again seizes upon them and reconstructs them into protein.

Having now answered the question as to what a plant is, so far as to be able to say wherein it differs from members of the other kingdoms of nature, we will briefly consider the same question from what may be called the vegetable point of view.

The Life of a Plant.—It is not our province to discuss what life is, and in speaking of the life of a plant we only mean to describe the different phases between the birth and death of the plant.

Let us choose some common garden plant for an illustration—one, such as the mignonette, which is sown as seed in spring and dies in autumn.

Take a single seed and examine it. It consists of two distinct portions fitting closely together, called *cotyledons*[1], between which lies a little curved body, the *germ*. The cotyledons are surrounded by a seed-coat, which must be removed before they can be distinguished.

From the germ the future plant arises, and during the earliest stage of its existence it is nourished by stores of protein matter contained in the two cotyledons.

To all appearance the seed is dead, but it possesses the power of springing into active existence under the influence of warmth and moisture. The vital powers are sleeping, and not dead.

The seed is planted, moisture and warmth act upon it, the cotyledons swell and burst the seed-coat. But the nutriment stored in the seed is in the form of insoluble starch and other matters, and as the plant can only take up nourishment in the liquid form the starch is useless.

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[1] All the terms used in this chapter are derived, and further explained, in the chapters which treat specially of them.

We have, however, learned[1] that insoluble starch can be converted into soluble sugar, and when the seed begins to *germinate*[2] this process at once takes place, so that the young plant has a plentiful supply of food ready at hand.

One portion of the germ grows upwards to form the *stem*, and the other downwards to form the *root*.

If at this stage we take the plant and examine it microscopically, we shall find it to consist entirely of minute bladder-like bodies called *cells*. These cells consist of an outer wall of cellulose, and an inner coating of protein. The substance formed by the aggregation of the cells is called *cellular tissue*. At this period, then, the plant is entirely composed of cellular tissue.

Now, this is a very important fact, and we may here lay down the law, that *all the growing portions of a plant are first formed of cellular tissue.*

Eventually the stem peeps above the ground, and two leaves, corresponding to the two sections of the seed, are developed. These leaves differ from subsequent leaves in always being of a simple oval shape; and this is true of all plants whose seeds are formed of two parts like the mignonette.

Another fact now presents itself. Whereas all the parts of the plant were white or yellowish, no sooner does the stem appear above ground than a *green* colour is apparent in both stem and leaves. If our seed had germinated in a dark cellar the green colour would have been wanting. Hence we conclude, that *the green colouring matter of plants is only developed under the influence of light.*

The two first leaves soon die away. The plant increases in size—the stem growing in length and thickness and developing leaves—the root branching

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[1] P. 7. [2] L., *germinatus*, springing from a germ.

and throwing out fine fibres. We have now an opportunity of seeing that the exposed portions of the plant are covered with a skin of cellular tissue called the *epidermis*, the only portions free from this skin being the tips of the root fibres. We shall hereafter see that another portion is free from epidermis at a more advanced stage of plant-life.

The plant now begins to acquire considerable dimensions, and the elastic cellular tissue could scarcely maintain it in an erect attitude. Some of the tissue begins to undergo a transformation by the deposition of *lignine* in the cells, and eventually the original cellular tissue is absorbed, and a strong tissue, called *fibrous*, or *woody tissue*, remains in its place. Woody tissue, then, is formed from cellular tissue.

As the plant grows, little cellular protuberances are formed, which eventually become leaves. In the bud they are entirely composed of cellular tissue, but woody tissue is developed in the veins as they grow older, in the manner just described.

When the plant has arrived at maturity the buds no longer develop into ordinary leaves, but break into *flowers*. The early stages of a leaf-bud and flower-bud are exactly the same; indeed, *the parts of a flower are nothing more than leaves transformed into peculiar shapes for certain purposes.*

The flower consists, firstly, of a series of green leaf-like parts called *sepals;* secondly, of a number of coloured parts called *petals*, which, in the plant under notice, are united; thirdly, of a series of pin-like bodies, with little knobs on the top, called *stamens;* and lastly, of a greenish body in the centre, called the *pistil.*

Now each sepal, petal, stamen, and part of the pistil represents a transformed leaf, and under some circumstances they revert to their original leafy character.

The flowers open. The little knobs of the stamens

become filled with grains of a yellow substance called *pollen*; the top of the pistil, which has no epidermis, grows somewhat larger, and a sticky substance exudes from it.

Each pollen grain is a single cell. At a certain time the knobs open and the pollen is discharged, some of it falling upon the top of the pistil, where it sticks.

While these changes have been going on in the stamen, equally important changes have been taking place in the pistil. The lower portion swells out into a body called the *ovary*, which is divided into chambers, in each of which several white egg-like cells are formed. They are, in fact, the eggs of the plant, and are called *ovules*.

We must now return to the pollen adhering to the top of the pistil. Each grain develops a cell, which penetrates the tissue of the pistil; and from the end of this cell another is developed, and so on until a long cellular thread is formed right down the pistil into the ovary. It then enters the ovary, and approaches an ovule, into which it also enters by a little channel, and discharges itself. This process is called the *fertilisation* of the ovule. Without it no seeds could be formed.

The fertilised ovule now rapidly swells, and eventually becomes a seed such as that with which we started.

The mother plant, in the meanwhile, has lost its vigour, and soon after the seed is fully ripe it droops and dies.

Throughout this section we have spoken of the *growth* of the plant. Let us say a few words on the mode in which it grows. The roots take up mineral matter dissolved in liquid. This liquid passes up the stem of the plant into the leaves, which possess little openings called *stomata*. Much of the water is

evaporated from the stomata, carbonic acid is absorbed from the air, and the fluid becomes thickened. The fluid, or *sap*, now descends the plant, depositing fresh material throughout its course. In this way the various tissues are formed.

Résumé.—1. Living matter is distinguished from mineral matter by the presence of protein.

2. Plants differ from animals in having the power to form protein.

3. Protein is present in all living bodies.

4. The earliest condition of all plants is a cell or a number of cells.

5. All parts of a plant are developed from cells.

6. The plant derives its nutriment chiefly from the soil by means of the roots, and partly from the air by means of the leaves.

CHAPTER III.

CELLS AND TISSUES.

Cells are usually little, transparent, bladder-like bodies, having the outer skin or *cell-wall* of cellulose (p. 7). They generally contain fluids, and often little grains also of such material as *starch* and *chlorophyll*.[1] They are *flexible*, and hence are easily bent or crushed out of shape; *elastic*, and can, therefore, resist pressure; and *permeable*,[2] so that fluids can make their way through the cell-wall. These three qualities of *flexibility*, *elasticity*, and *permeability*, are essential properties of cells.

Shape.—The sphere is considered to be the true or

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[1] See pp. 6 and 9. [2] L., *per*, through; and *meo*, to go.

normal[1] form of the cell, but it is by no means so frequently met with as other forms. It is only where the cells are comparatively free that the spherical cell can be found. The reason is that growing cells press upon each other, and accommodate themselves to the varying pressure by reason of their flexibility. The particular form which cells assume depends largely, therefore, upon the pressure they undergo, the direction in which that pressure is applied, and perhaps to some extent upon the mode in which the cells are developed.

Cell Structure.—The cell consists essentially of a *cell-wall*, a lining of protein matter (p. 11), called the *primordial*[2] *utricle*, and an *internal fluid*. Besides these essentials many cells when fully formed develop a little disc, which becomes attached to the cell-wall, and is called the *cytoblast*[3] or *nucleus*.[4] The cytoblast sometimes contains smaller bodies, which receive the name of *nucleoli*. Fig. 1, Gr. i., shows a spherical cell, having a *nucleus* or *cytoblast*, which contains nucleoli. It is highly magnified.

Cell Formation.—Cells are formed in four different ways.

1. By isolated[5] formation in the protein fluid called *mucus*.[6] In this way the first cells of all tissues must originate.

2. By contraction of the primordial utricle, which eventually cuts the cell in two, and forms two distinct cells. This method is called *fissuration*.[7] It may be seen among the *algæ*, or seaweeds.

3. By division of the nucleus into two or four portions, which give rise to new cells. This may be termed *endogenous*[8] formation. It occurs in the production of the pollen of flowers.

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[1] L., *norma*, a rule. [2] L., *primordialis*, first, original; and *utriculus*, a small skin. [3] Gr., *kutos*, skin; and *blastema*, a germ. [4] *Nux, nucis*, a nut. [5] L., *isolus*, alone, separate. [6] Latin. [7] L., *findo, fissum*, to split. [8] Gr., *endon*, within; *genao*, to produce.

4. By the shutting off of a portion of the cell-wall so that a new cell is formed, attached like a bud to the outside of the parent cell, whence this mode is called *gemmation*[1], or budding. It may also be termed the *exogenous*[2] mode of formation. This may be observed in some algæ, liver-worts, characeæ, and fungi.

By fissuration and endogenous formation the original or parent cell is destroyed. This is not the case in gemmation.

A.—CELLULAR TISSUE.

Description.—Great numbers of cells growing in contact unite into a membrane, which is called *cellular-tissue.* At first it is exceedingly thin, and mostly transparent, but it usually acquires greater consistency as it grows older. This thickening process is sometimes continued to such an extent as to give the cellular tissue a firm, solid texture.

Lacunæ.—The aggregation[3] of cells is not always perfect, and small spaces may often be detected between the cells; these are termed *inter*cellular[4] *spaces*, or *lacunæ.*[5] Lacunæ are sometimes formed by the contraction of the sides of the cells, giving to the cells a star-shaped or *stellate*[6] appearance when cut across. When numbers of such cells are placed one above the other, passages are formed, as may be seen in the stems of rushes and the leaf-stalk of the water-lily. Fig. 2, Gr. i., represents a section of the stem of a rush, showing the stellate cells and the intercellular spaces.

Parenchyma.—A slight pressure, exerted equally on all sides of spherical cells, would convert them into twelve-sided cells, or dodecahedrons,[7] which would appear six-sided or hexagonal[8] when cut across. This

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[1] L., *gemma*, a bud. [2] Gr., *ex*, outward, and *genao*. [3] L., *aggrego*, to bring together. [4] L., *inter*, between, and cellular. [5] L., *lacuna*, a gap. [6] L., *stella*, a star. [7] A dodecahedron is a twelve-sided figure. [8] A six-sided figure.

is the most general form of cellular tissue, and to it the name of *parenchyma*[1] has been given. Of it the soft green tissue of leaves, &c., is formed.

Other names have been given to modifications of this tissue, which present appearances different from those of hexagonal parenchyma. These varieties only occur sparingly, and are generally merely parenchyma under different influences of pressure, &c.

Fibro-cellular Tissue, &c.—In the leaves of some mosses, in the fleshy, colourless underground leaves of certain plants, and in other situations, a peculiar form of cellular tissue exists. The cells, instead of being simple as in the case of the tissues we have been describing, have a thickening of the wall, forming a spiral thread, coiled up as it were in the interior (Fig. 3, Gr. i.). The tissue formed of these cells is named *fibro-cellular* tissue. Sometimes the thread is not continuous, but appears as a series of rings or dots, instead of a spiral (Figs. 4, 5, Gr. i.). This may arise from the elongation of the cell after the spiral fibre has been deposited, when a rupture of the spiral would ensue. Or the transverse bars may show where the thickening has been arrested, the cell-walls being thinner, instead of thicker, at those points. Spiral fibres are also imbedded in mucus on some seed coats, and the cells themselves adhere to each other by this same mucus.

Sclerogen Cells.—In some cells the thickening has gone on to such an extent as to convert the cell into an almost solid mass. But even here spaces occur where the thickening has been arrested, and where the thin cell-wall appears. These spaces are so arranged as to be opposite similar spaces in adjacent cells, so that the fluid contents can pass through the cell-walls from one cell to another. Such cells are

[1] Gr., *parenkuma*, the substance of the lungs, liver, &c.

called *sclerogen*[1] cells. They are found in the stones of the plum, cherry, and date, in the shells of nuts, in vegetable ivory, &c. Thin slices present a very beautiful appearance under the microscope.

Pitted Tissue consists of a series of elongated cells placed end to end, and hence appears to be jointed, or *articulated*.[2] The cells are pitted over with little spots, from which the tissue is named. It is also called *bothrenchyma*. Pitted tissue seems to be an intermediate stage between ordinary cellular tissue and the vascular tissue to be next described. It is found most frequently in close proximity to continuous vessels of a similar character. In fact, in some of the large grasses the tissue may be traced in regular gradations from parenchyma, through pitted tissue, to continuous vessels. The pitted tissue is seen in the blade of the leaf, the articulations becoming more distant towards the base, and ceasing altogether in the sheath, where the tissue becomes *continuous bothrenchyma*. There can be little doubt that the two forms, articulated and continuous, have the same origin, and should be considered as different conditions of the same tissue.

Bothrenchyma enters largely into the structure of stems, veins, and the more solid parts of plants. The pores seen in sections of wood, cane, &c., are passages, formed of this tissue. They are sometimes very large especially in plants of rapid growth, and are formed in greatest abundance during the period when the vegetative force is most active. Fig. 6, Gr. 1, represents this kind of tissue.

Conclusion.—As protein forms the chemical basis of all plant structures, so cells are the medium through which protein works. This is also true of

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[1] Gr., *skleron*, to make hard, and *genao*.

[2] L, *articulus*, a joint.

animal matter, all animal, as well as vegetable substances, being formed from protein, and the first structure formed by protein being always a *cell*. Every plant, indeed every part of a plant, has once been in a cellular condition; and some plants (mosses, sea-weeds, lichens, and fungi) are composed entirely of cellular tissue. The lowest plant-forms consist of a single cell only, and all plants are in this *unicellular*[1] condition at one point in their development, namely, in the pollen-grain and ovule.

B.—VASCULAR TISSUE.

Woody Tissue or **Pleurenchyma** consists of slender tubes of a *fusiform*, or spindle shape, tapering at each end. The sides are cylindrical, transparent, and tough; they lie together in bundles, and only communicate with one another by permeation through the walls. Woody tissue may be easily recognised by its toughness and attenuated form. The walls of pleurenchyma become thickened by successive deposits of *lignine* (p. 7), and when cut across, the concentric markings of the deposit may, in some instances be traced, as in the woody shell of the cocoa-nut and the fibrous portion of bark (*liber*). (Figs. 7, 8, Gr. i.)

The great toughness of this tissue renders it a most valuable vegetable product. Hemp, flax, and jute consist of it, separated from the other tissues of the plants from which they are obtained by *maceration*,[2] that is, by steeping in water until the soft parts decay, and then brushing them away, leaving only the woody tissue. The separation is not complete, nor, indeed, is this necessary. It is the presence and continuous arrangement of this tissue which gives to *wood* its distinguishing character. In palms the woody tissue is separated by cellular tissue, hence there is so little cohesion that

[1] L., *unus*, one, and cellular.
[2] L., *macero*, to soften by steeping.

it is impossible to get a board out of them; the most compact only furnish a few walking-sticks. Fig. 6, Gr. i., gives a representation of pleurenchyma.

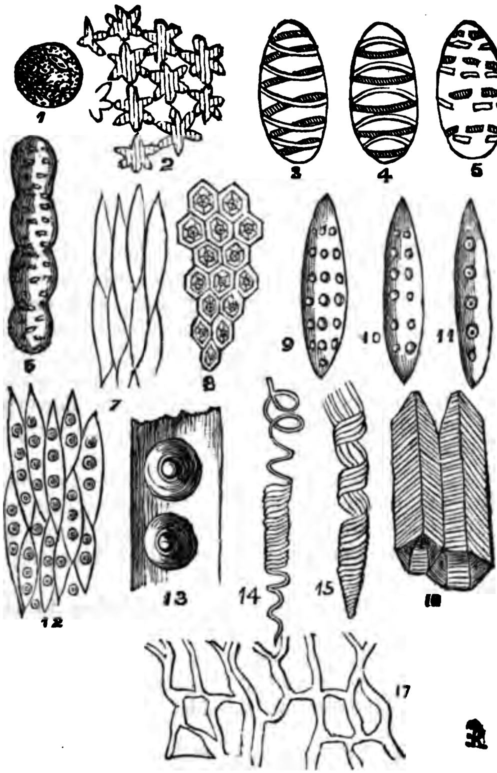
A variety of pleurenchyma, called *glandular tissue*, is formed chiefly in the pine-tribe and in the cycadaceæ, a tribe of plants closely allied to the pines. The tubes are of larger dimensions than in the other forms, and their sides are furnished with circular discs, sometimes in single, sometimes in double or triple rows. These discs have small holes in the centre, and are so arranged as to be opposite to and in contact with the discs of adjacent tubes, so that they communicate with one another. The rows of discs in the same tube are placed opposite to each other, so that it is easy to see through them when under the microscope.

In selecting shavings of pine to show this tissue, care must be taken to procure sections of the proper portions of the tubes, for no discs will be seen in some parts.

Glandular tissue is very common in coal, hence we know that coniferous and cycadaceous trees contributed largely to the production of that mineral. It has also been found in a few aromatic trees. Illustrations of it are given in Figs. 9 to 13, Gr. i.

Fibro-vascular Tissue *or* **Trachenchyma**[1] consists of thin cylindrical tubes, with a spiral, thread-like process coiled in them. This thread may be likened to a fine wire which has been wrapped close round a needle. The tubes taper at each end, and are originally in contact with one another at those points, but the parts in contact rapidly become absorbed, so that a communication is kept up through a long series of them. In roots, stems, leaf-stalks, veins and flower-stalks, the tubes are packed together in masses, but in the flower they are more sparsely distributed.

[1] *L.*, *trachea*, windpipe or neck; and Gr., *egchuo*, to pour in.



GROUP I.

1. Cell, with cytoblast and nucleoli.
2. Stellate tissue and lacunæ of rush.
3. Fibro-cellular tissue (spiral).
4. Ditto ditto (rings).
5. Ditto ditto (dots).
6. Pitted tissue.
7. Woody tissue.
8. Ditto, showing deposits of lignine.
9. Glandular tissue.
10. Glandular tissue.
11. Ditto.
12. Ditto.
13. Ditto (much magnified).
14. Fibro-vascular tissue.
15. Ditto.
16. Scalariform tissue.
17. Laticiferous tissue.

In the leaves of the *Strawberry* they are abundant and large, and may be readily seen by breaking a leaf asunder, when the parts will remain connected by the drawn-out spirals which appear as little green cords. These can be removed and placed on a glass slide for microscopic examination, and their form seen to perfection. It must be remembered that the act of pulling has destroyed the enveloping membrane of the tissue.

The spirals frequently consist of more than one thread, and the distance between the whorls varies. They are sometimes exceedingly fine, and require a good magnifying power to distinguish them, while in some rapidly growing parts of tropical plants they are large enough to be distinguished by a good pocket glass. An instance of this is seen in the flowering axis of the banana. Figs. 8, 14, 15, Gr. i., are representations of fibro-vascular tissue.

Annular Ducts.—A distention of the enveloping membrane after the formation of the spiral coil, will cause the latter to break up into rings, which are called *annular ducts*, the word duct meaning a passage.

Scalariform Tissue.—When in addition to this distention which forms the rings, the vessels become compressed, so that the rings appear like bars, the tissue is called *scalariform*,[1] from a fancied resemblance it has to the steps of a ladder. Fig. 16, Gr. i., shows this tissue.

Cinenchyma *or* **Laticiferous Tissue** differs from all those hitherto described, in being ramified, the branches running into one another and forming an irregular network. The sides of the tubes also are not parallel, as in other tissues, but are contracted in some parts and distended in others in an irregular manner. Some-

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[1] L., *scala*, a ladder.

times the passage is almost closed up by the contraction, but there is always a through communication between the whole of the tissue, however complicated the system may be. Through this tissue a turbid fluid flows, which is thick in some plants and thin and watery in others. This fluid is called *latex* and the tissue through which it flows *laticiferous*, that is, *latex-bearing*. The milky juice that exudes from some plants when they are cut, as the *dandelion*, is latex, and therefore the product of this tissue. Cinenchyma is not found in all plants, and is, perhaps, confined to the class Exogens, and to a limited number of them.

In some plants it is found on the under-surface of all parts of the plant, as in the *campanula;* in others it is limited to the young shoots, as in the *hedge-maple.* It may be studied with advantage in the bracts of the common *bindweed,* also in stipules of the india-rubber plant of our nurseries. The bracts of the bindweed are sufficiently transparent to allow transmitted light to pass through them. The stipules of the india-rubber plant can be split and the upper and lower surfaces separated. The lower surface bears the laticiferous tissue, and if the specimen be prepared quickly and dexterously, the flow of the latex may be distinctly seen.

In some plants the latex moves slower than in others, and the rate of motion is far from uniform in different parts of the same plant.

In one, if not more, of the common spurges the latex contains numbers of prismatic bars, the nature of which, so far as we know, has not been determined.

In warm climates many valuable products are obtained from the latex, as, for example, opium, and caoutchouc or india-rubber. Fig. 17, Gr. i., represents this tissue.

Résumé.—The cell is the first formed and the simplest of all the vegetable structures. Aggregations of cells form cellular tissue, and every plant and every part of a plant is formed from this tissue.

Spaces called *lacunæ* are sometimes left between the cells, and in some cases these form passages through the substance of the plant.

The most common form of cellular tissue is that called *parenchyma*, in which the cells by pressure assume a dodecahédral form and give a hexagonal section.

In some cells fibres or thickenings of the cell-wall are found, and to this variety the name of *fibro-cellular* tissue is given. When the cells are filled up by deposits of this thickening material they are called *sclerogen* cells.

Vascular tissue is a higher development than cellular, and is produced from it. The cells are no longer visible, and their place is supplied by little tubes of hardened matter. The simplest form of vascular tissue is the *pitted tissue*, in which the original cells are not altogether destroyed.

Fibro-vascular tissue bears the same relation to ordinary vascular tissue as fibro-cellular to cellular tissue.

Glandular tissue is a peculiar variety found only in pines and cycadareous plants.

Pleurenchyma, or woody tissue, is distinguished by its toughness and the elongated form of its component tubes. It is this tissue which gives to certain plants their woody nature.

Cinenchyma, or *laticiferous* tissue, consists of a series of branching and connected vessels similar to the veins in the human body. Through them flows a fluid called *lάtex*.

We have divided the tissues into two classes—

cellular and *vascular*—and the different forms of these may be tabulated as follows :—

Cellular.	Vascular.
Cell.	*Tube.*
Parenchyma.	*Pleurenchyma.*
Fibro-cellular tissue.	*Fibro-vascular tissue.*
Spirals.	Spirals.
Dotted.	Dotted.
Pitted tissue.	*Glandular tissue.*

CHAPTER IV.

THE EPIDERMIS

Description.—The epidermis is a layer of compressed cells, with fluid contents destitute of green colouring matter. It covers the whole surface of plants, with the exception of the stigma and the extremities of the fibrils of the roots. Its cells are bounded either by *sinuated*[1] margins, or by margins more or less parallel.

Structure.—The epidermis may be readily removed from those parts near the veins projecting from the back of the leaves, when young, or it may be separated entirely by maceration. When taken from leaves of a persistent character, like those of the *holly*, its cells will be found to have very thick walls, coated externally by a *pellicle*[2] of varnish-like substance, which is secreted by the cells. This is probably *protein*, and is of the same nature as the matter that causes the cells and vessels of plants to cohere in the form of a tissue.

Epithelium.—The lining of the anthers,[3] the ovary,

[1] L., *sinus*, a bend. [2] L., *pellicula*, a little film. [3] The top of the stamen.

and other internal parts of plants, possesses a very thin covering, which is termed an *epithelium*. In the epithelium of the anthers the cells are marked by bands, spirals, discs, and many other beautiful forms, which make them fine objects for the microscope.

Epidermis of submerged Leaves.—The leaves of submerged plants, such as *potamogeton* and others, have an epidermis so far imperfect that the only part that can be made out is the transparent pellicle that is secreted on the surface.

Stomata.—Openings of a peculiar character exist in certain parts of the epidermis. They are called *stomata*, and are found in the greatest abundance on the backs of leaves exposed to the air. They are fewer in number on the upper surfaces of such leaves that have a horizontal direction; and are about equally disposed on the two surfaces of leaves whose direction is vertical. Leaves that have a floating habit, as those of the *water lily*, have stomata only on their upper surface. Plants that are wholly submerged are destitute of them.

Stomata are disposed, with more or less regularity, over the epidermis of the green parts of plants; sometimes singly, at others in clusters. Sometimes they are sunk in depressions between the veins of the leaf, and can only be detected by making sections, and cutting across them.

Structure.—Stomata are usually formed by the development of two contiguous cells in a lunate[1] form, the hollow sides of which face each other. An opening is thereby left in the epidermis, communicating with the intercellular spaces of the parenchyma, by means of which transpiration is regulated.

Stomata are represented in Figs. 2, 3, Gr. ii.

Conditions of the Epidermis.—Besides the stomata

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[1] L., *luna*, the moon; crescent-shaped.

there are also other appendages and conditions of the epidermis, which, being constant and distinctive of certain plants, must be studied and compared. A *farinaceous*[1] or *mealy* condition of the epidermis is found in several species of *Primula*.[2] When examined microscopically it seems to be amorphous,[3] that is, it does not possess any distinct shape. It is secreted by the epidermal cells at an early period, preceding the unfolding of the leaf.

The *scurfy*, or *scaly* condition is also very distinct in some plants, as *Eleagnus* and *Hippophœ*, where all the exposed epidermis is covered with scales; this condition is called *leprous*.[4] It differs from the farinaceous condition in the distinct form of the excrescences, which are closely packed and stellate. The extremities of the rays curve at the extremities as if revolving. The stars are fixed in the centre, and are therefore *peltate*.[5]

Other conditions also occur as:—

Viscid, or *glutinous*; that is, covered with a sticky exudation.

Glaucous,[6] covered with a fine bloom, as may be seen on a cabbage leaf.

Ramentaceous[7] covered with weak, shrivelled, brown scale-like bodies, as the stipes of many ferns.

Squamous,[8] scaly, covered by minute scales, like the young branches of the pine tribe.

Paleaceous[9], chaffy, covered with small, erect, weak membranous scales, as may be seen on the receptacles of many compound flowers.

There are many other conditions of the surface, for which a glossary of terms may be consulted.

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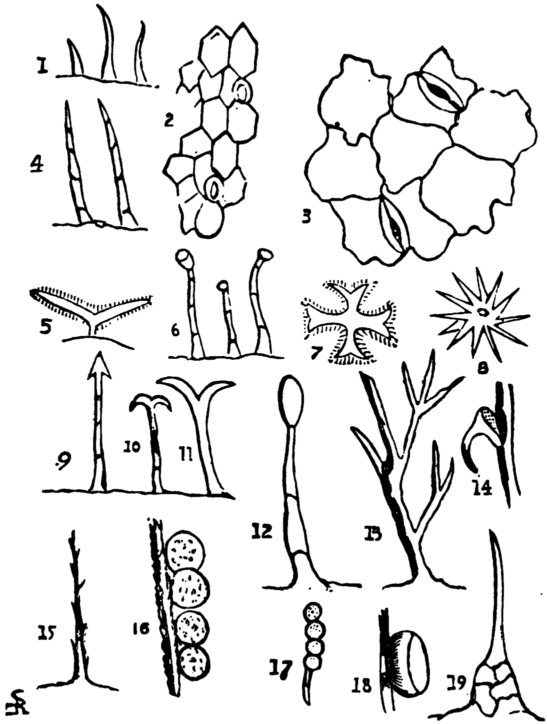
[1] L., *farina*, meal. [2] The primrose. [3] Gr. *a*, without, *morphe*, form. [4] L., *lepis*, a scale. [5] L., *pelta*, a buckler. [6] L., *glaucus*, bluish grey. [7] L., *ramenta*, scrapings. [8] L., *squamosus*, covered with scales. [9] L., *palea*, chaff.



GROUP II.

1. Simple hairs.
2, 3. Cuticle with stomata.
4. Hairs formed of several cells.
5. Peltate hair.
6. Capitate hair.
7, 8. Stellate hair.
9. Barbed hair.
10, 11. *Uncinate* hair.
12. Clavate hair.
13. Branched hair.
14. Prickle.
15. Hair of poppy
16. Glands of sage.
17. Glands.
18. Ditto.
19. Ditto.

Appendages.—The most important appendages of the epidermis are *hairs* and *glands*. They are composed of one or more cells, and are either simple or branched.

Hairs.—Simple hairs may consist of a single cell, or of several placed in opposition. They may be persistent or *deciduous*.[1] They vary greatly in length, texture and form; thus they may diminish from the base upwards, or they may expand in that direction, in which case they are called *clavate*[2] or club-shaped.

The apex may curve downwards, when they are termed *uncinate*,[3] or hooked.

They may have several hooks around the apex; they are then termed *barbed.*

When they are attached in the centre and branch in opposite directions, they are said to be *peltate.*

When the apex has a distinct round head, they are said to be *capitate.*[4]

Stellate hairs are those in which several hairs radiate from a common centre. They are found on many plants of the cabbage tribe, the mallow tribe, and on parts of numerous other plants.

It frequently happens that the hair on the upper surface of a leaf differs in character from that upon its lower surface. The coats of many seeds have hirsute appendages, such as those of the cotton plant. Hairs are also found on the ovule of *Philadelphus coronarius.*

Different varieties of hair are shown in Figs. 1, 4 to 13, and 15, Gr. ii.

When hairs become hardened they are called *prickles*, as in the case of brambles and roses. These prickles must not be confounded with spines, as they are nothing more than appendages of the epidermis, while spines are branches arrested in their development. Hairs are formed at a very early stage in the develop-

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[1] L., *decido*, to fall off. [2] L., *clava*, a club. [3] L., *uncus*, hooked. [4] L., *caput*, a head.

ment of a leaf. Fig. 14, Gr. ii., represents a prickle, partly detached.

Glands are hair-like appendages containing secretions[1] in the cells at their bases, or in those at their apices. These secretions may be acrid and stinging, as the nettle, or fragrant volatile oil, as in sweet briar. (Figs. in Gr. ii.)

Varieties of Surface.—The number, strength, and distribution of hairs on the surface give certain appearances and conditions, which are thus distinguished :—

Pubescent,[2] or downy; *sericeus,*[3] or silky; *hirsute,*[4] shaggy; *velutinous,*[5] velvety; *lanate,*[6] woolly; *scabrous,*[7] rough; besides many other forms, for which a glossary had better be consulted. Warts and *papillose* excrescences also occur on different parts of the epidermis.

When the epidermis is free from appendages or scurf it is naked or smooth, and is called *glabrous.*[8]

The circulation of the fluids may be seen in the hairs of some plants, by means of a good microscope. Spiral fibres are said to be coiled up in the hairs of *Drosera* (Sundew). As a rule, stomata and hairs occupy different positions, stomata occurring between the veins, and hairs usually predominating on their surface.

CHAPTER V.

THE DESCENDING AXIS, OR ROOT.

Definitions.—The main portion of a plant, or that which supports the other parts is called the *axis,*

[1] A secretion is a substance, liquid or solid, which is deposited by any organ. [2] L., *pubes*, hair. [3] L., *sericcus*, silky. [4] L., *hirsutus*, shaggy. [5] It., *vellutinus*. [6] L., *lanatus*, woolly. [7] L., *scaber*, rough. [8] L., *glaber*, smooth.

and consists of two parts, the *root* and the *stem.* As the root grows downwards, it is called the *descending axis,* and as the stem grows upwards, it is called the *ascending axis.* The point of union between the stem and root is called the *collum,* or *neck.* From it the plant grows in opposite directions, the stem ascending and the root descending.

Forms of Root.—The size of the root is to some extent dependent upon the nature of the plant, large plants having stronger roots than small ones. A root may penetrate into the earth to a great distance, or it may be confined to a slight depth below the surface. It may also be either a simple descending axis, or a tangled mass of fibres, every gradation being found between the two. The colour varies from white to all shades of brown, and is never green.

In *dicotyledonous*[1] plants, or such as have two seed-lobes, the root is developed from a part of the seed called the *radicle,*[2] which after germination continues to grow and enlarge according to the nature of its species, the root consisting of a single axis extending downwards some distance, and then becoming more or less branched; or it may become branched immediately on entering the soil and so present a mass of *fibrils*[3] emanating from a single point.

In *monocotyledonous*[4] plants, or such as have only one seed-lobe, the radicle perishes soon after germination, and *rootlets*[5] are developed from its base. These rootlets are termed adventitious—a term that will be more fully dwelt upon presently (p. 34).

Structure.—The structure of the root is a central column of cellular tissue, extending to the extremities of the fibres. Around this column is an envelope of

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[1] The buttercup, geranium, &c., and most trees belong to this class. [2] L., *radex,* a root; radicle means a little root.
[3] A little fibre. [4] The lily, grasses, &c., belong to this class.
[5] Little roots.

fibrous tissue, reaching nearly to the extremities of the fibres. This envelope is encased by a cellular covering, which extends to, and joins the extremity of, the central cellular column, overlapping both it and the fibrous envelope. The extremity of the root is, therefore, a combination of two distinct cellular systems. In this region of cellular tissue, cell formation and cell destruction is continually going on, nutriment in a fluid condition being absorbed from the soil.

The epidermis of the root is destitute of stomata, or organs of respiration, and its branching fibrils are irregular in their arrangement.

Collum.—The collum, or neck, is sometimes marked by a distinct swelling of the base of the stèm, but in some plants is quite indistinguishable.

Function.—The function of the root is twofold: first, to fix the plant in the ground; second, to seek for and help to supply the plant with nourishment.

Adventitious Roots.— Roots are sometimes developed which do not spring from the radicle, and are hence called *adventitious*.[1] Of this nature are the fibrils of monocotyledonous plants, before described (p. 33).

Plants are increased for horticultural purposes by the promotion of adventitious roots. These grow naturally from various parts of some plants, principally from the base of the leaf or leaf-stalk beneath the axil.[2] They may be promoted by heat and moisture, even from the surface of the leaves, in the case of a few plants. A simple, or only slightly branched root, generally termed a tap-root, is the most common form of root.

Buds on Roots.—In some few plants, under certain conditions, leaf-buds are developed from various parts

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[1] L., *ad*, to, and *venio*, to come, accidental. [2] The point of union between the leaf-stalk and stem.

of the surface, and even from the extremities of the root. This may be observed in some *alpine*[1] or *saxatile*[2] plants, when storms, floods, or other disturbances have washed away the soil, leaving the roots exposed to the influence of light and air. This fact may be readily verified by exposing in a similar manner roots of the rock *Alyssum* (A. saxatile) of the gardens, when leaf-buds will develop as we have described. Any one who has grown aloes in pots may have seen the fibres turned upwards, when impeded in their growth by the sides of the pots. When the fibres reach the surface a leaf-bud forms, and a new plant is produced.

Names of Roots.—When large and succulent, and tapering gradually from the neck to the extremity, as in the parsnip and carrot, the root is termed *conical.* (Fig. 2, Gr. iii.)

When it enlarges below the neck, and again gradually contracts, as in the beetroot and radish, the root is termed *fusiform.*[3] (Fig. 3, Gr. iii.)

If it enlarges laterally[4] still more, and contracts again suddenly, becoming almost globular, as in the turnip, it is termed *napiform.*[5] (Fig. 4, Gr. iii.)

If a root enlarges laterally below the neck, and then contracts, and again enlarges and contracts, continuing that mode of growth, so as to appear like a number of lumps strung on a thread, as in some grasses, it is termed *moniliform.*[6] (Fig. 1, Gr. iii.)

If the contractions are close and narrow, resembling ligatures, as in the ipecacuanha, the root is termed *annulose.*[7] (Fig. 7, Gr. iii.)

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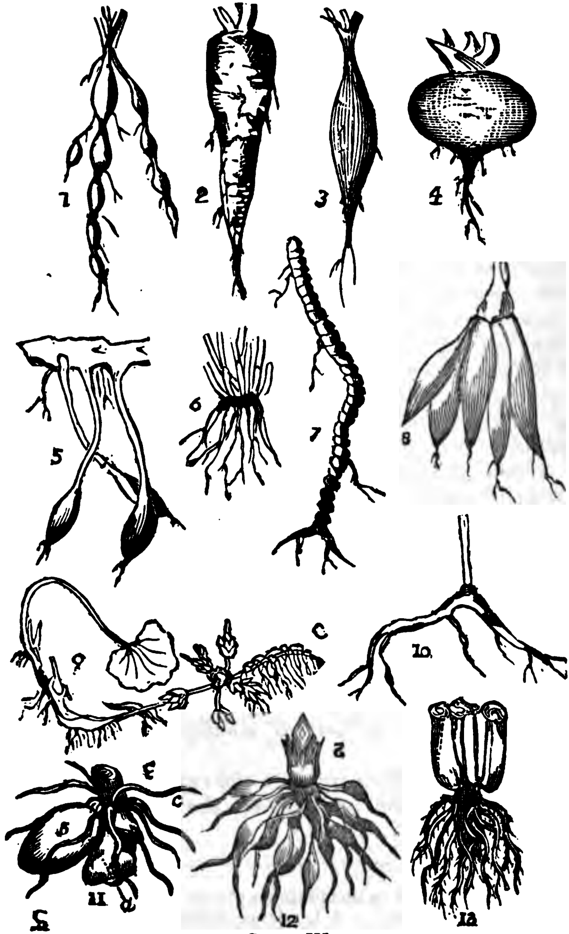
[1] Plants belonging to mountainous plants. [2] L., *saxatilis*, growing among rocks. [3] L., *fusus*, a spindle. [4] L., *lateralis*, sideways. [5] L., *napus*, a turnip. [6] L., *monile*, a necklace. [7] L., *annulosus*, ringed.



GROUP III.

Moniliform.	4. Napiform.	7. Annulose.	10. Præmorse (bitten).	12. Fasciculated
Conical.	*5. Nodulose.*	8. Fasciculated.	11. Tubercular.	13. Fibrous tap-root.
Fusiform.	*6. Fibrous.*	9. Granular.		

When some of the rootlets become succulent towards their extremity, so as to appear like suspended weights, as in *Spiræa filipendula* and *Scrophularia nodosa*, the root is termed *nodulose*.[1] (Fig. 5, Gr. iii.)

When all the rootlets become succulent and are attached to a common point, as in the dahlia, the root is termed *fasciculated*.[2] (Fig. 8, Gr. iii.)

If, instead of a single axis, there are a number of rootlets of nearly uniform description proceeding from or near a common point of attachment, as in grasses, sedges, &c., it is called a *fibrous root.* (Fig. 6, Gr. iii.)

When some of these rootlets become enlarged and succulent, assuming a *palmate*[3] or *ovate*[4] form, as in the orchis, the root is termed *tubercular*.[5] (Fig. 11, Gr. iii.)

These examples may be considered as typical forms, but as the divergences are unlimited, many other terms are employed to distinguish the chief of them.

CHAPTER VI.

THE ASCENDING AXIS, OR STEM.

Description.—The stem, or ascending axis, of a typical plant grows vertically either permanently or at least during some portion of its existence. It differs still further from the descending axis in bearing leaves. In some plants the leaves are reduced to the condition of hair or bristle-like processes,[6] while the axis itself becomes expanded, succulent, and green, and performs the functions of leaves. A few plants

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[1] L., *nodulosus*, knotted. [2] L., *fasciculus*, a little bundle.
[3] L., *palma*, the palm of the hand; here meaning *fingered*.
[4] L., *ovum*, an egg. [5] L., *tuber*, a swelling. [6] A process is a projection.

have the axis destitute of leaves until the period of flowering, when floral leaves are developed in due course, and are the only distinct appendages[1] which the plant possesses. The axis itself may produce excrescences of a disc-like form, which will adhere to any body that they may come in contact with, like so many suckers. These discs are not appendages of the axis, but only modifications thereof.

Nodes.—As the stem of a typical plant grows, leaves are developed at regular intervals. The point on the stem from which a leaf springs is termed the *node*;[2] and the spaces between the leaves are termed the *internodes*.[3] When the leaves are so crowded that the internodes cannot be distinguished, they must always be assumed to be present. Such stems are often described as stemless, but this is inaccurate. The stem does exist, but the internodes are so depressed as to be imperceptible.

Duration—The growing parts, or tops, of stems and their branches are green, soft, and *herbaceous*.

Many stems exhibit this appearance throughout their whole surface, and the stems are then called *herbaceous* stems. Such stems seldom have a longer duration than one year, when either the entire plant dies, or the stem dies back to the neck, or collum, from which a new stem is produced the following year. Plants that perish entirely within the year are called *annuals*.[4] Those plants whose stems only die back to the crown or neck, and are renewed again the following season, are distinguished as *herbaceous perennials*,[5] though the stems themselves are strictly annual. Perennial stems are generally of a firmer, harder, and more tenacious substance than those of annuals, and

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[1] L., *appendicula*, a small appendage. [2] L., *nodus*, a knot. [3] L., *inter*, between, and *nodus*. [4] L., *annus*, a year. [5] L., *per*, through, and *annus*—living through many years.

only possess a herbaceous character in their younger portions. They endure for a number of years without perishing.

Biennial[1] plants and biennial stems are such as produce their leaves, or foliar[2] organs, during the first year after germination, and their floral[3] organs and seed in the second season; after which the plant perishes.

Branches.—When, in the course of its growth, a stem divides, the divisions are called branches. The system upon which this process of branching is developed is called *ramification.*[4] The younger shoots sometimes have special names; thus, the twigs are termed *ramuli.*[5]

Trees, Shrubs, and Herbs.—By differences in the constitution of the branches and in their ramification, plants are divided into *trees*, *shrubs*, and *herbs.*

If the branches are perennial, and supported on a trunk, as in the oak, the plant is called a *tree.* When the branches are perennial, proceeding directly from the surface of the earth, without any supporting trunk, as in the rose, the plant is called a *shrub.*

When the stems and branches are woody, but perish annually or partially so, we have the *under-shrub.* This is intermediate between the shrub and the herb, or the herbaceous stem. And whether plants are herbs or under-shrubs often depends on climatal conditions, a plant which is a herb in some spots becoming an under-shrub in more favourable circumstances.

Direction.—At the commencement of this chapter it was implied that the ascending axis might not always continue to grow in a vertical direction. The bud usually has a vertical direction; but in many

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[1] L., *bi*, two, and *annus*. [2] L., *folium*, a leaf; leaf-like.
[3] L., *flora*, a flower; flower-like. [4] L., *ramus*, a branch; and *fio*, to make. [5] L., *ramulus*, a little branch.

plants, as the leaves are developed, and the stem elongates, the latter being of a soft, yielding texture, as in the vegetable marrow, instead of rising erect, lies on the surface of the earth, and is called *prostrate.*[1]

If a stem is only prostrate when young, and acquires strength and rigidity as it increases in age, so that the base is prostrate and the summit erect, as in the *Ajuga reptausa,* it is said to be *ascending.*

Prostrate stems have a tendency, especially when growing in a moist situation, to throw out roots from the axils of the leaves, as in the moneywort. These are called *creeping stems.*

In some few plants the stem, after being erect during the development of two or three internodes, appears suddenly to give way at the base, and falls prostrate; the summit, as it continues to grow, assuming an erect position, so that the stem appears like a bent knee, as in the *Alopecurus geniculatus.* This is termed *geniculate.*[2]

Stems, which, without being sufficiently strong to stand by themselves, are not prostrate upon the ground, have a tendency to support themselves by different means upon other bodies in their neighbourhood. Such are *climbing plants.*

Such stems as support themselves by twisting round adjoining substances, are termed twining plants, or *volubiles.* These always wind themselves in a determinate direction, constant, according to their species. The direction, for example, is always from left to right in the *hop,* and from right to left in the *kidney bean.*

Stems that climb by means of their appendages are termed *scandent.*[3]

Hollow Stems.—Many stems, owing to the rapidity of their growth, become hollow. The central cellular

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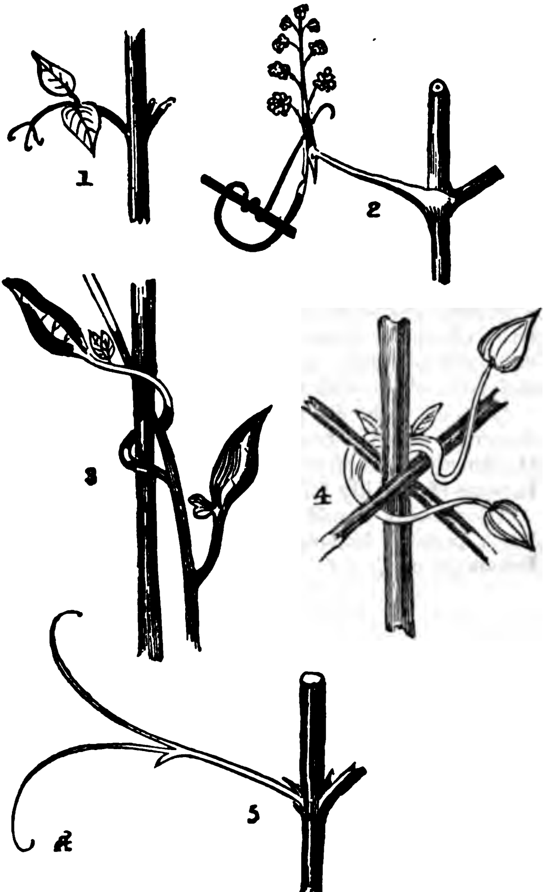
[1] L., *prostratus,* lying down. [2] L., *genu,* the knee; *knee-like.* [3] L., *scandens,* climbing.



GROUP IV.
Scandent Stems.

tissue not being generated to a sufficient extent to keep pace with the lateral distension of the axis, becomes ruptured, and eventually dries up. Such stems are termed *fistular*.[1]

It must be borne in mind that all stems are originally solid, and are always solid at the apex. Some are perceptibly *articulated*,[2] or jointed, at intervals. Sometimes the articulation takes place at every leaf, or in other instances at every branch. Stems may be also imperceptibly articulated, the articulations being only revealed when having arrived at maturity, the stem falls away a joint at the time. Others have the appearance of being articulated, without really being so; as many of the grasses and canes, and some of the pink tribe.

In some instances the ascending axis is only the flowering axis in structure, although it may perform the functions of leaves as well. Examples are found in some of the lily tribe.

The student should observe the growth of some of the numerous bulbous lilies, and the plant called Solomon's seal.

CHAPTER VII.

THE ASCENDING AXIS—(continued).

EXOGENOUS STEMS.

Structure.—By reason of the differences observed in the internal structure of stems, and in the methods by which they increase their diameter, the vegetable kingdom is divided into three great

[1] *L., fistula*, a pipe or tube. [2] L., *articulus*, a joint.

classes—viz., *Exogens*,[1] *Endogens*,[2] and *Acrogens*.[3] These differences are accompanied by marked distinctions in other organs, which render it comparatively easy for the student to determine to which class a plant belongs without mutilating or destroying it.

Exogens are those which increase by additions to the exterior, as our timber trees, and very many herbs, as the buttercup. The parts of the flowers are generally arranged in fives or multiples of five.

Endogens are those which increase from the inside, as grasses, canes, and palms. They possess no wood or bark, and the parts of the flower are arranged in threes and multiples of three.

Acrogens are those which increase from the summit, as ferns. They produce no wood or flowers, their reproductive organs being placed on the surface of the leaves.

These few distinctive features are sufficient for our present purpose. The student will find the classes more fully explained hereafter.

Exogenous Stems possess a more complex organization than those of any other class. But although the most complex, the facilities for examination are so numerous that they are, perhaps, the best understood of any.

All timber trees belong to this class; and they vary greatly in the proportion and density of their various tissues. An examination, however, of sections of British trees and shrubs will enable a person to readily distinguish their general structural character.

Section of Oak.—If, for example, we make a transverse section of a young *oak* (Fig. 1, Gr. v.), we shall distinguish—

First, a small central portion, say a quarter of an

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[1] Gr., *exo*, outwards, and *genao*, to produce. [2] Gr., *endon*, inwards [3] Gr., *acros*, the summit.

inch in diameter, which is soft and yielding. This is composed of cellular tissue, the cells of which, owing to the pressure being equal on all sides, presents a hexagonal outline. This portion is termed the *medulla*,[1] or *pith*, and, in the timber trade, the *centre* (*a* Fig. 1, Gr. v.). It becomes obliterated as the tree advances to maturity.

Second, we distinguish an external coat, which is separable. This is known as the *cortex*, or *bark* (*b* Fig. 1, Gr. v.).

Third, we have, between the cortex and the medulla, a mass known as the *wood* (*c* Fig. 1, Gr. v.).

These are the three visible and primary distinctions, and are sufficient in themselves to indicate an exogenous stem.

There are other features characteristic of exogenous stems, some of which may serve to show more clearly why they are so designated, namely :—

(*a.*) *Medullary Sheath.*—Surrounding the medulla is a ring or sheath of spiral vessels ; this is called the *medullary sheath.*

(*b.*) *Medullary Rays.*—Numerous lines radiate from the medullary sheath, and traverse the wood to the circumference. They sometimes penetrate a short distance into the bark, as in the beech ; or even pierce through it, as in the ivy. They consist of compressed cellular tissue, called *muriform*, from the wall-like appearance it presents when magnified. As the stem increases in diameter other lines originate, but all extend outwards to the circumference. All these lines are known as the *medullary rays.* They may be very thin and almost imperceptible, as in *box-wood*, where they consist, perhaps, of only a single series of cells; or they may be of considerable thickness, and give a decided pattern to the wood, as in *oak* or *sycamore.*

[1] L., *medulla*, pith.

They also have a considerable influence on the manner in which the wood splits: when they are thick, it splits readily in their direction (*d* Fig. 1, Gr. v.).

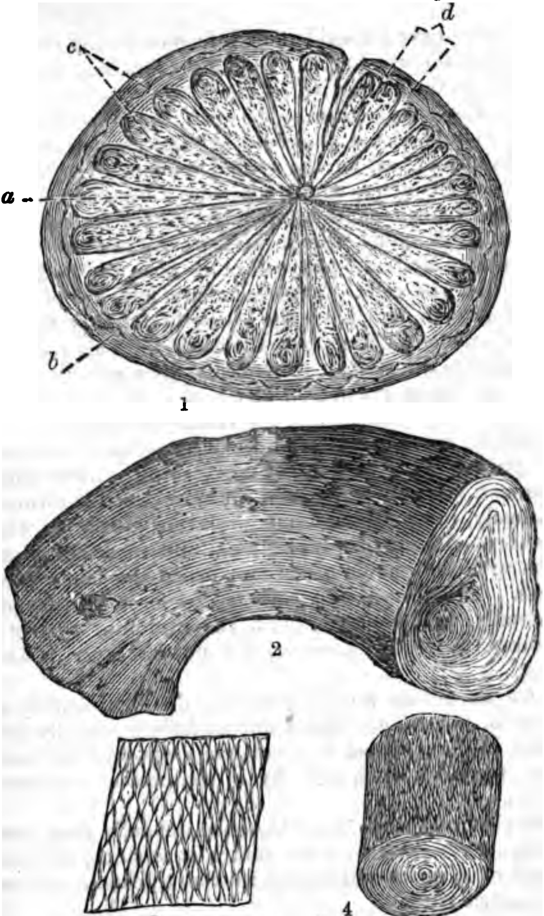
(*c.*) *Cambium System.*—Between the wood and the bark may be seen a semi-fluid substance—it is in that condition at least in the early summer—of a highly nutritive character, which nourishes a peculiar cellular system, known as the *cambium system*, or *cambium cells*. It is more correct, perhaps, to use the term "cambium system," as a collective term for both the fluid and the cells. These cambium cells are of very rapid growth, and have the power of forming tissues of a character different from themselves. This they do in opposite directions. Outwardly, they generate the *liber*, or inner portion of the bark; inwardly, they generate woody tissue and the vessels of the wood.

Taking into consideration the alternation of seasons of growth with seasons of rest, or of winter with summer, we shall understand that new wood is formed annually, in concentric rings or layers *out*wardly, the last formed being always external and in communication with the cambium system; hence the name exogens. The liber of the bark is also formed in layers annually, in connection with the cambium system; unlike the wood, however, the newest layer is inside.

An exogenous stem is therefore distinguished by a *medulla*, a *medullary sheath*, and *medullary rays*, by the wood being arranged in *concentric rings*, by a distinct and separable *bark*, and by a continuous *cambium system*.

Position of the Medulla.—The medulla does not always correspond with the centre of a stem; neither is there a strict uniformity in the thickness of the concentric rings.

During cold and short summers, the formation of wood will take place slower than when the summer is



GROUP V.

1. Section of oak—*a*, medulla ; *b*, bark ; *c*, wood , *d*, medullary rays.
2. *Ivy stem, showing* eccentricity of the medulla.
3, 4. *Bark of ash,* showing the interlacing vessels of the liber.

long and warm. If, from any cause, a plant is not properly nourished, the formation of new material will be retarded. Consequently, the concentric rings are seen to vary in thickness in relation to each other, and also in opposite portions of the same ring.

If the light and air are diminished on one side of a tree, the formation of new material will be less on that side than on the other which is fully exposed. Twining stems of a woody character show this very distinctly, the part in contact with the support developing the smallest amount of new material, the medulla getting in time nearer the circumference than the centre. (Fig. 2, Gr. v.)

Structure of Wood.—The wood will be found to consist of porous or pitted vessels, cellular tissue, woody fibre, and spiral vessels. The vessels are frequently large enough to be seen in section without any artificial aid; at other times they are too minute to be distinguished without a powerful lens. The woody fibre is mostly in compact masses, the vessels being more or less scattered about. In some woods, conspicuously in *ash*, the vessels are aggregated together chiefly at the inner circumference of each woody ring.

Heart and Sap-wood.—If we observe the wood of *mahogany*, *ebony*, *rosewood*, and many other trees, we notice that the external portion is of a whitish or yellowish colour, while the interior is much darker. The internal, or dark-coloured portion is distinguished as the *heart-wood* or *duramen*,[1] and is the only part used in manufactures. The outer, and light-coloured portion is distinguished as the *sap-wood* or *alburnum*.[2] It is only in this latter portion of the wood that vital force exists. In the dark-coloured portion (the duramen) the tissues have become corroded and ceased to act.

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[1] L., *duramen*, hardness. [2] L., *albus*, white.

As the tree increases in age, the proportion of duramen to alburnum increases. There is, therefore, more waste in young timber of this description than in wood which is fully matured.

Very few of our native trees show distinctly the separation of heart and sap-wood; nor can it be said by any who have had experience in working those woods that there is any real distinction while the wood is sound. But in very old trees, the heart-wood begins to decay by disintegration of the tissues gradually taking effect from the centre to the circumference. The wood is then called *doaty* by those who have to do with it, and should always be rejected.

The brown oak used for domestic furniture is of this nature, the rich colour being caused by incipient[1] decay. It is quite useless for out-door purposes, or where strength is required; but, used as veneer or for ornamental work, in contrast with other woods, it is valuable. It is, however, so unconvertible, so wasteful, and so difficult to work, that it is never in favour either with manufacturer or workman.

The Bark, or outer of the two principal portions of an Exogenous tree, differs from the wood in its structure and mode of growth. Like the wood, it is deposited in concentric layers, but the layers are found to be by no means uniform in all trees, when we come to examine them. The outer portion of the bark is the oldest, and the inner the newest, the order of development being the reverse in the wood.

Perfect bark is composed of three distinct kinds of tissue, besides the epidermis. First, the *epiphlœum*;[2] second, the *mesophlœum*;[3] third, the *endophlœum*, or liber.

The *Epiphlœum* consists of flat, tabular cells, vary-

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[1] The early stage.
[2] Gr., *epi*, upon; and *phlois*, bark.
[3] Gr., *mesos*, middle.
[4] Gr., *endon*, within.

ing in thickness in different barks; being sometimes very thin-walled; and at others thick-walled and tough, as in the *cork oak*, some *elms* and *hedge-maple*. It is sometimes easily separable from the layers below it, and is cast off periodically.

The *Mesophlœum*, or middle layer, is developed generally to a less extent than the outer. The cells are of a different form, being round or elliptical, smaller, and not generally so compact; and sometimes presenting considerable inter-cellular spaces. These cells are also at one time thick-walled, and at another thin-walled. They sometimes multiply rapidly, and decay as quickly. By this means they assist in throwing off the outer layer, or *Epiphlœum*.

It is in this middle layer that the *laticiferous vessels*,[1] having connection with the vascular system of the leaves, are found.

The *Endophlœum*, or *liber*, is the fibrous, or vascular, layer of the bark. A fresh layer of this portion of the bark is formed annually, and in some barks these layers are separable.

The fibres are remarkable for their flexibility and tenacity, and are of great value for textile fabrics, cordage, yarns, and ropes. *Hemp*, *flax*, many *Malvaceous*[2] plants, *nettles*, the *lace-bark* and the *lime-tree*, contribute material for these purposes.

The layers are termed the *cortical*[3] layers, the latest formed layer being always internal.

In the *grape vine*, after a few years' growth, a portion of the liber is thrown off annually. Probably these cortical layers are the only portions of the bark developed from the Cambium after the first year. They are certainly the largest portion.

Growth.—Having enumerated the different tissues in the bark, and shown their relative position, it may

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[1] See p. 25. [2] The *mallow* tribe. [3] L., *cortex*, bark.

E

be well to describe the process of its formation year by year. Let us take the *Ash* by way of illustration. Its growth being rapid in the early stages, and the tissues large, it will be more easily understood.

On making a transverse section[1] of a one year old shoot, the epidermis will be seen on the outside. Beneath it will be found some closely compacted, round, or slightly elliptical cells, imbedded in which are vascular bundles (*the liber*), consisting of a ring of liber cells, with one open vessel to each ring; the vessel being always on the side of the ring nearest the circumference of the stem. The interior of the ring is filled up with cellular tissue. These vascular bundles, when examined in a longitudinal direction, are found to be straight, parallel, and at equal distances from each other. The ring is, therefore, a vascular envelope composed of small tubes, imbedded in cellular tissue. The interstices or channels between the small tubes have, therefore, a larger portion of cellular tissue between them and the epidermis than there is between the external part of the small tubes and the epidermis.

This is the first cortical layer, and consists only of two portions of the true or perfect bark. The vascular portion is capable of no farther increase or extension, whereas the cellular portion rests during the winter, and is called into action again in the ensuing summer.

In the second year another cortical layer is formed beneath the former, which is consequently forced outwards by the intervention of the new one. The small tubes, or, as we must call them, the vascular bundles of the first cortical layer, are separated from each other, and somewhat distorted; while the cellular

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[1] That is, a piece cut at right angles to the length of the *branch*, or such as would appear round. A cut in the opposite *direction would give a longitudinal section*.

portion begins to work again, forming new cells between the displaced vascular bundles. This continues year after year, till about the sixth or seventh year, when the external and first-formed of the cortical layers becomes distorted and distended into an elongated network, the interstices of which are filled up with tabulated cells (the *epiphleum*) that have been generated by the elliptical cells of the *mesophleum.*

The outer cortical layer may be observed beneath the epidermis in the growing tree till about the twelfth year, after which it gradually becomes covered with the increasing epiphleum.

A transverse section of an ash, about ten years of age, will show the arrangement of the vascular system of the bark to be like a cog-wheel with the cogs set at an acute angle, the apex of the teeth being the first cortical layer, and the bases of the teeth representing the latest formed cortical layer; or like a series of triangles with their bases turned inwards. The interstices between the teeth are filled with the tabulated cells of the epiphleum, the mesophleum (representing only a very small portion) resting on the cortical layers. The epiphleum is, therefore, clearly developed from the mesophleum.

It has been said by some authors that there is, probably, no true bark the first year. This is only partially true. If we examine the *hedge-maple,* we find, in a stem of the second year, a layer of the mesophleum developing itself. The same condition may be observed, after one season's growth, at the base of an axis of that season, so that the development of bark is only a question of rest or direction of force, which may differ in different barks.

CHAPTER VIII.

ENDOGENOUS STEMS.

Endogenous Stems, of which palms and grasses may be considered the types, differ from exogenous stems in having neither a distinct central pith nor a complete and independent bark. In external appearance they are nearly cylindrical, while exogens present a more or less conical form.

Internally, endogenous stems present a cellular mass, which is traversed by the vascular bundles, that are developed in the leaves and continued into the stem. These vascular bundles consist of laticiferous vessels, spiral vessels, woody tissue resembling liber, cambium cells, large porous vessels (*bothrenchyma*), with, perhaps, a portion of parenchyma. The vascular bundles differ from the wood of exogens in the presence of laticiferous tissue and spiral vessels. (Fig. 2, Gr. vi.)

The direction of the bundles is from the base of the leaf-stalk in a curve towards the centre of the stem, whence they soon diverge towards the circumference, crossing previously formed bundles in their progress. During their downward and outward growth the different tissues gradually disappear, till only woody fibre of a liber-like character reaches the circumference, where it forms a kind of tangled network covered with a thin *epiphleum*, which serves the purpose of bark, but has not the independent character of a true bark. (Figs. 1 and 3, Gr. vi.)

This structure causes the stems to be most dense and hard at the circumference, more especially towards the base.

Palms are of little use as timber; the external portions of a few are sometimes made into such small articles as walking-sticks and parasol-handles. They take a high polish, and are not readily broken, owing *to the interlacing* of the fibres. The internal and more

cellular portions of many of them yield *starch*, *sugar*, and other valuable products.

Palm stems present a jagged outline externally, owing to the projecting bases of the petioles, which are many years in decaying. There being no articulation between the leaf and the stem, there is, consequently, no fall of the leaf in most endogens.

In *grasses* the stem is mostly hollow between the nodes, the fibres at those points crossing over to the other side of the stem, and by interlacing, forming partitions which divide the stem into a many-chambered cylinder. The hollowness is produced by the rapid distension of the stems, which causes the rupture and the destruction of the cellular portion. The apex is, of course, always solid.

Some *arborescent*[1] endogens present the appearance of having a bark if the stem be cut transversely. This is caused by the crowded leaf bases persisting[2] round the stems. They sometimes form a covering two inches thick, and of sufficient cohesion to be cross-cut with a saw.

There are a few herbaceous endogenous stems which, being destitute of foliar organs, perform the function of leaves, as some of the *rushes*.

Modification of Cells.—Inasmuch as the vascular system is generated in the leaves, endogenous stems, when leafless, must necessarily be of a cellular character. As these stems are comparatively slender, and have to support a considerable weight of floral appendages, a peculiar modification takes place in the form of the cell. The sides appear contracted, as though they cease to grow at certain regular intervals. This gives them, when cut transversely, the appearance of stars (Fig. 2, Gr. i.), and as the radii of contiguous cells only are in contact, there are, consequently, large intercellular spaces, which impart to the stem the same elasticity as if it were traversed with vessels.

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[1] L., *arbor*, a tree ; tree-like. [2] Not falling away.

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Some *arborescent*[1] endogens present the appearance of having a bark if the stem be cut transversely. This is caused by the crowded leaf bases persisting[2] round the stems. They sometimes form a covering two inches thick, and of sufficient cohesion to be cross-cut with a saw.

There are a few herbaceous endogenous stems which, being destitute of foliar organs, perform the function of leaves, as some of the *rushes*.

Modification of Cells.—Inasmuch as the vascular system is generated in the leaves, endogenous stems, when leafless, must necessarily be of a cellular character. As these stems are comparatively slender, and have to support a considerable weight of floral appendages, a peculiar modification takes place in the form of the cell. The sides appear contracted, as though they cease to grow at certain regular intervals. This gives them, when cut transversely, the appearance of stars (Fig. 2, Gr. i.), and as the radii of contiguous cells only are in contact, there are, consequently, large intercellular spaces, which impart to the stem the same elasticity as if it were traversed with vessels.

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[1] L., *arbor*, a tree ; tree-like. [2] Not falling away.

envelopes the bases of the decayed stipes, which in like manner encase the cellular column of the true stem, or the cavity where it formerly existed.

A transverse section of one of these trunks, taken at the base of a stem twelve inches in diameter, such as *cyathea*, will show in the centre a cavity one inch in diameter, surrounded by a ring of hard vascular tissue, interspersed with cavities from which the cellular tissue has disappeared; this ring will be about three inches in diameter, and is composed of the remains of the stipes, or foot-stalks, of the leaves. The remainder of the section, and by far the largest portion, is nothing but matted root-fibres, of which, perhaps, the largest part have performed their function. They thus give support to an organism of which they have ceased to be a living part, and may be compared to the dead base of a coral reef which supports the living surface.

If we take a section of the same stem near the summit, we shall find—

First:—A central cellular disc of the same diameter as the cavity in the former section, the cells containing much *starch.*

Secondly:—A somewhat irregular ring composed of vascular and cellular tissue; the cellular either partly decayed or perfect. This will be of the same diameter as the corresponding portion of the former section, and have the same origin.

Thirdly:—Fibres, constituting the remainder of the section, but bearing only a small proportion to the other parts, not averaging half an inch in thickness. In this part we may expect, in the living plant, to find life more or less active. The fibres are living roots, reaching down to the earth, or wherever they may find moisture to nourish the leaves and stem above. The central cellular stem, though incapable of further extension in that part, aids the part above by contributing nourishment.

The old and dead root fibres may also assist the young roots in obtaining a supply of moisture by means of capillarity.

The student will perceive from this description, and by examining specimens, to be found either in museums or at the nursery gardens, that it is only by the comparative indestructibility of the dead organism that the living one is sustained above the earth. In the more cylindrical forms, where the roots do not envelope the stem, they penetrate the interstices of the decaying leaf bases, and probably derive nourishment from the decaying matter till they reach the soil. All parts of the root, except the extremities, become encased in a horny epidermis, which gives them a wiry character.

Fossils.—Although numerous ferns are *scandent*,[1] it is doubtful if any acrogens are *volubile*[2]—*i.e.*, have twining stems. Acrogenous stems, of gigantic proportions, are found in a fossilized condition in the different coal-fields over the globe.

Several ferns are said, by Berkley, to have spiral vessels in their stems, sparingly in the centre.

CHAPTER X.

CREEPING AND SUBTERRANEAN STEMS.

Under this title are grouped together several forms of the ascending axis, the majority of which are either wholly or partially developed underground. Some of them are commonly, though incorrectly, called roots, with which they have nothing in common except their underground habit. Roots do not develop leaves even in the most rudimentary form. Neither do they form nodes, though they may, and sometimes do, develop

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[1] L., *scandens*, climbing. [2] L., *volubilis*, twining.

buds. In these points subterranean stems differ from roots.

Classification.—The *rhizome*[1] is the most common form of this kind of stem or root stock. (Fig. 6, Gr. vii.) This is a fleshy stem, creeping along under the surface, or sometimes partially above the soil. It forms roots on its under-side, and on its upper leaves, which are sometimes developed uninterruptedly, at others only at intervals. At certain seasons some rhizomes branch in a fork-like manner, the surface often bearing the scars left by fallen or decayed leaves. The garden flag—*Iris germanica*—is the commonest example of this form. The *wood anemone* may be given as another. It is common in ferns.

The *sobole*[2] (Fig. 4, Gr. vii.) is a creeping, underground secondary axis, or branch. It is more slender than the rhizome, and forms roots on its under-surface, and on its upper fleshy or scale-like leaves. From the axils of these another axis is developed, which rises above the ground and becomes more or less erect. The *Bindweed*, *Calystegia sepium*, &c., are examples.

The *tuber*[3] (Fig. 5, Gr. vii.) is a secondary axis, subterranean in habit, in which the leaves and the stem become blended into a common mass, having depressions, popularly called *eyes*, which indicate the dormant[4] buds. The *potato* and the *Jerusalem artichoke* are familiar examples. The species of *maranta*, which yields the arrowroot of commerce, will show the true nature of this form of stem. The blending of the scales not being complete, the stem is seen to be simply an axis with appendages.

Bulbs (Figs. 2, 3, Gr. vii.) approximate most nearly to tubers in being a combination of axis and appendages. They are the depressed stems of some mono-

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[1] Gr., *rhizon*, a root. [2] L., *sobole*, a sprout. [3] L., *tuber*, a knob. [4] L., *dormeo*, to sleep ; not developed.

cotyledonous plants, surmounted by succulent, scale-like leaves. They are distinguished as *tunicated*[1] bulbs (Fig. 2) when the leaves are continuous, and enclose each other, as in the *onion;* and *scaly* or *bulbous*, when they are in scales, as in many *lilies*.

These two forms—the tuber and the bulb—though usually classed with stems, are more of the nature of subterranean buds.

The *corm*[2] (Fig. 1, Gr. vii.) is a depressed stem, and differs from the bulb in being solid and independent of appendages, the resemblance being only external. The *crocus*, *gladiolus*, &c., afford examples.

Pseudo-bulbs are green, bulb-like bodies, developed above ground on certain orchidaceous plants. They usually form at the bases of the leaves, are very hard externally, and incapable of an independent existence.

The *sarmentum*,[3] or *runner*, is a prostrate, filiform,[4] secondary stem, forming at its extremity roots and leaves, and producing a new plant, which itself gives birth to fresh runners, as the *strawberry*. This form is called by some botanists the *flagellum*.

The *surculus*, or *sucker*, is a secondary axis, which proceeds from the neck of a plant, beneath the surface, becoming erect when it reaches the surface, and then quickly developing leaves, and subsequently roots, on the portion below the surface. The *rose* is an example.

The *propagulum offset* is a secondary axis developed in the axils of the leaves, and terminating in a rosette of leaves, which subsequently forms roots, and eventually leads an independent existence, as in the *house-leek*.

Note.—Bulbs are not exclusively subterranean in their origin, as several lilies develop small bulbs or bulbils in the axils of their leaves; while some kinds of onion even develop them among the flowers.

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[1] L., *tunicatus*, clothed. [2] Gr., *kormos*, a stem. [3] L., *sarmentum*, a twig. [4] L., *filiformis*, thread-like.

GROUP VII.

SUBTERRANEAN STEMS.

1. *Corm.*
2. *Tunicated* bulb (section).
3. *Scaly bulb.*
4. Sobole.
5. Tuber.
6. Rhizome.

CHAPTER XI.

LEAF BUDS.

Introduction.—The stem possesses certain appendages called leaves, which are developed from buds. A leaf-bud may produce one or many leaves according to the species. The point of junction between the leaf or leaf-stalk and the stem is called the *axil.*[1]

Leaf-buds either form the extremity or growing points of branches, or are produced in the axils of leaves previously developed; in the first case they are called *terminal,* and in the second *axillary.* Occasionally they burst through other parts of the axis, when they are called *adventitious.* Sometimes a cluster of buds surrounds a terminal bud; these are termed *accessory.*

Leaf-buds, in temperate and cold regions, have two states of existence. The one may be called the *hibernating,*[2] or winter condition, in which the tender growing point is protected by hard brown scales. The other may be termed the *vernal,*[3] or spring condition, in which the scales fall away and the green leaves are developed.

Growth.—The winter bud consists of the internal growing point, and the external scale-like appendages arranged in a spiral or imbricated[4] manner. The scales are either consolidated together with a gummy or resinous secretion, or protected with a close down of soft hairs. These scales have only a temporary duration on the plant, and are mostly cellular, with the exception of a few laticiferous vessels. Collectively they form the *hibernaculum.*[5]

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[1] L., *axilla,* the arm-pit. [2] Hibernating is the sleep-like condition in which the growth appears to be arrested. [3] L., *ver,* spring. [4] L., *imbrex,* a roof-tile. [5] L., *hibernaculum,* a winter residence.

The cicatrices[1] left when these scales are shed, are persistent in some trees for several years, and by observing the length of the axis between one group of scars and the next, the amount of growth that has taken place in one season can readily be ascertained.

As the bud expands out of the winter condition into the vernal, a change takes place in the structure of the scales which are then produced. Under unfavourable conditions the axis is slowly prolonged, and another cluster of scales, terminating in a closed bud, is developed. Under favourable, or ordinary conditions, simultaneously with the elongation of the axis, transition scales are developed, which are larger than those that preceded them, and sometimes have a partial vascular system. These are followed by true leaves, having their cells distended with chlorophyll and fluids, and possessing a perfect vascular system.

In some instances scales that have only a temporary existence are developed alternately with the true leaves, as in the *hazel* or the *lime-tree.*

Vernation.—The arrangement of leaves in the bud, and the mode in which they are folded up, form what is called *vernation,*[2] and is governed by fixed laws, which differ in different plants.

Of the different modes in which the leaf is folded, the following may be considered the typical and most common.

The *involute,*[3] in which the margins of the leaf are rolled inwards on the face. They may be rolled or folded along the whole length from base to apex; from the base to the centre only; or, from the centre to the apex only. This form of vernation is very common. (Fig. 3, Gr. viii.)

Revolute,[4] with the margins rolled back on the under-

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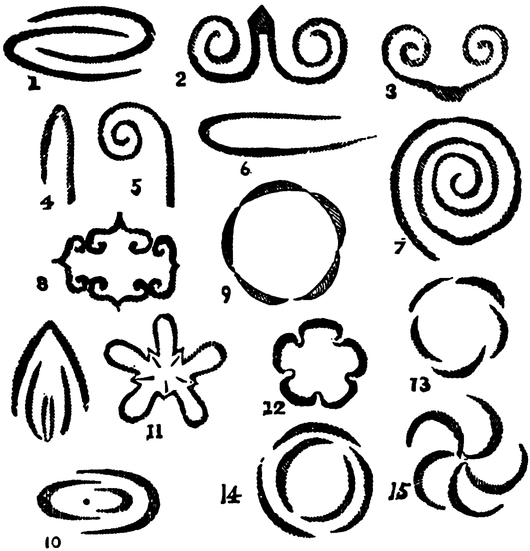
[1] L., *cicatrix*, a scar.
[2] *Vernus*, belonging to spring.
[3] L., *in*, and *volvo*, to turn.
[4] L., *re*, back.

surface of the leaves, as in the *butter-burr* and *rosemary.* (Fig. 2, Gr. viii.)

Convolute,[1] the leaf being rolled upon itself; having one margin on the face of the leaf, and the other margin with its face to the back of the first, as in the *apricot.* (Fig. 7, Gr. viii.)



GROUP VIII.

1. Obvolute.
2. Revolute.
3. Involute.
4. Reclinate.
5. Circinate.
6. Conduplicate.
7. Convolute.
8. Induplicate.
9. Valvate.
10. Equitant.
11. Induplicate.
12. Spiral.
13. Do.
14. Do.
15. Contorted.

Reclinate,[2] in which the apex of the leaf is bent back on to the base, as in the *tulip-tree.* (Fig. 4, Gr. viii.)

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[1] *L., con,* together. [2] L., re, back; clino, to lean.

Conduplicate,[1] in which the leaf is folded back laterally, as in the *oak.* (Fig. 6, Gr. viii.)

Circinate,[2] that is, rolled from apex to base, as in *drosera,* or, more completely, in *ferns* and *cycads.* (Fig. 5, Gr. viii.)

Plicate,[3] when folded in several plaits, as in *ladies' mantle* and *grape-vine.*

The arrangement of leaves round the axis in the bud, and their relation to each other, produce combinations, which are named as follow :—

Valvate,[4] when they are on the same plane and touch each other by their margins, as in the flower of *clematis.* (Fig. 9, Gr. viii.)

Imbricated,[5] when lapped over each other at different levels, like the tiles on a house, as in the *lilac.*

Twisted, or spiral, when the margin of one leaf overlaps that of another, as in the flower of *Phlox.* (Figs. 12 to 15, Gr. viii.)

Induplicate,[6] when two opposite leaves are folded in, and touch at their margins, as in *columbine.* (Figs. 8 to 11, Gr. viii.)

Equitant,[7] when the leaves are folded inward, so that the outer leaf covers the inner with its margins, as in the *privet.* (Fig. 10, Gr. viii.)

Obvolute,[8] when folded so that the half of one leaf covers the half of another, *i.e.,* when they are half equitant. (Fig. 1, Gr. viii.)

Bulbs.—Many perennial plants form their buds only on the lower portion of the axis, at or below the level of the soil. Among buds of this kind may be classed bulbs, the leaves of which are either thick, fleshy scales, as in the *lily,* when they are called *scaly* bulbs; or continuous round the axis and round each other, and

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[1] L., *con,* and *duplico,* to double. [2] L., *circino,* to turn round. [3] L., *plica,* a fold. [4] L., *valva,* folds. [5] L., *imbrex,* a roof-tile. [6] L., *in,* and *duplico,* to fold. [7] L., *equitans,* riding. [8] L., *ob,* round; *volvo,* to turn.

are then called *tunicated*, as in the *onion*. New bulbs are formed in the axils of these leaves, and occasionally along their margins, as in *Lilium auratum*.[1]

Bulbils.—In the axils of some leaves consolidated bodies are formed, which, when detached from the plant and placed in the soil, produce young plants. These are found in some *begonias*, *ranunculus ficaria*, &c., and are known as *bulbils*.

Spines are sometimes developed in the position of leaf buds, and a leaf bud may be eventually transformed into a spine. Altered conditions may influence the prevalence of spines or leaf buds.

Tendrils may be produced by modification of the leaf bud. They belong to the habit of the plant, and result from the development of the axis and the absence of appendages. A somewhat opposite phenomenon may be observed in the buds of the larch, at an early stage, when numerous leaves or appendages are developed simultaneously, without any apparent elongation of the axis. A perfect leaf bud results in an axis, which is the foundation of other buds, which become the bases of secondary axes, and so on, to a great extent, in the case of exogens. In most endogens, however, buds are not formed so profusely.

Adventitious Buds cause considerable modifications in the figure and grain of wood. Bird's-eye maple, so much esteemed in cabinet-work, is an example of distortion of the grain arising from this cause. As soon as the tree has attained a good size, with a trunk of about nine inches in diameter, numerous adventitious buds are formed beneath the bark. The bark being very thick and compact, the buds are not developed externally, but only keep pace with the growth of the concentric rings of wood. Every season additional buds are formed, so that the more external

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[1] See p. 58.

the wood the richer the figure. A trunk cut through vertically, shows the two margins crowded with these beautiful eyes—the result of adventitious buds. They gradually diminish in number towards the centre, before reaching which they disappear entirely. This wood is used in thin sheets, called *veneer*. In order to obtain a large surface with the eyes in, the trunk is made to revolve against a fixed knife or cutter till the external part, containing all the rich figure, is removed; the central or plain wood is then left for more common purposes.

Excrescences known as *burrs* are also formed on the trunks of some trees by means of adventitious buds. They sometimes attain a large size, and often have in them the elements of decay, but are sometimes perfectly sound. When they occur in furniture-woods, they are of great value, as in *walnut*, *thuja*, *amboyna*, and a few others.

The shoots of some trees rest during the winter with a terminal bud, from which the axis is continued the next spring. Others have only lateral buds. Among the first are the *oak* and the *ash*. Among the latter is *willow*. The timber of trees having terminal buds has less lateral cohesion, and is more easily split than that of trees having only lateral buds. But when trees with terminal buds reach maturity, the terminal buds cease to have a preponderating influence, and the vegetating force becomes more equalized, consequently the lateral cohesion of the timber increases in this class of trees. It will be observed of this class that young trees split more readily than old ones, and that old ones split more readily near the centre than they do at the circumference.

Budding.—Buds are capable of being removed from one plant, and made to grow on another of the same family. This is practised by horticulturists on rose trees, and on various fruit trees. The buds are care-

fully removed with the base of the leaf stalk attached about the month of July, when they are well formed; every particle of wood must be cut away, leaving nothing but the bud and a portion of bark. An incision is then made in the ripe part of a growing shoot of a briar (if a rose is being operated upon), and the bud carefully inserted against the wood. The portion of bark attached to the bud is turned in under the bark of the briar, and is then neatly tied above and below the bud, and the operation is complete. A practised hand will do one hundred in an hour, and guarantee ninety out of them to take.

CHAPTER XII.

LEAF STRUCTURE.

Description.—The leaves, whose development we have just traced, are called *foliar*[1] leaves, to distinguish them from the modified leaves of the flower, which are termed *floral*[2] leaves.

Foliar leaves are the appendages of the axis of vegetation, as they are developed from the base of the growing point. A typical leaf consists of an expanded portion, called the blade or *lamina*,[3] and a stalk or *petiole*.[4]

The Petiole may be very short, or altogether absent. Sometimes it is expanded at the base into a sheath or *vagina*,[5] which clasps the stem, or into a cushion (*pulvinus*[6]), which rests against the stem.

Leaf-like expansions (partially formed leaflets), called *stipules*,[7] are sometimes developed at the base of the petiole, as in the *rose*.

A leaf-like expansion sometimes accompanies the

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[1] L., *folium*, a leaf. [2] L., *flora*, a flower. [3] L., *lamina*, a blade. [4] L., *petiolus*, a little foot. [5] L., *vagina*, a sheath. [6] L., *pulvinus*, a cushion. [7] L., *stipula*, a stalk.

petiole along its whole extent, and is called a *phyllodium*,[1] as in the *orange*.

The Lamina of a leaf is sometimes absent, a phyllodium performing all the functions of the leaf, as in the *goatsbeard*. The margins of the lamina may become united in development, forming a cylindrical leaf, as in the *onion*.

Development.—At first, leaves are wholly cellular. Under the influence of light, however, chlorophyll is formed in the cells of the parenchyma, throwing a flush of green over the whole of that portion of the leaf. The cells from which chlorophyll is absent belong to the cambium system (p. 45), which, at this stage, has the appearance of a series of colourless branches ramifying through a green ground. The next stage in the order of development consists in large numbers of the cambium cells becoming rapidly elongated in the direction of the length of the leaf. These cells lie parallel to each other, and the extremities of those in the same line come into contact. When they have ceased to multiply, the ends in contact become absorbed, and thus vessels are formed, constituting the vascular system of the leaf. By this time the leaf is nearly expanded.

By exposure to the atmosphere, the outer cells of the leaf become compressed, and form the epidermis, or *cuticle*.[2]

We find, therefore, that the leaf consists internally of *parenchyma*, a *cambium system*, and a *vascular system*; and externally, of a covering called the *cuticle*, or *epidermis*.

Succulent[3] leaves have their vascular system concealed by the mass of parenchyma which preponderates.

The Cuticle consists of cells, more or less compressed, and is generally thicker in texture on the

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[1] *Gr., phullon*, a leaf. [2] L., *cuticula*, the skin. [3] Fleshy leaves.

upper side of the leaf. These cells have sinuous or wavy margins in plants with net-veined leaves, and margins more or less parallel in plants with parallel-veined leaves. On the outside of the cuticle are found numerous small orifices or pores, called *stomata*.[1] (Figs. 2, 3, Gr. iii.) They are oval-shaped, and occur between two rounded or *lunate*[2] cells, known as the *guard-cells*. These guard-cells have the power of contracting or expanding, according to atmospheric influences, contracting and enlarging the orifice under the influence of atmospheric moisture; and expanding, closing the orifice, in dark or dull weather. Stomata are generally distributed with regularity over the surface, either singly or in clusters. On some *begonias* they are so distinct as to be discernible without the aid of a lens. They are never found on the veins, but always between them, and are considered to communicate with the intercellular spaces of the parenchyma. Leaves that lie in a horizontal position have a larger number of stomata on their under than on their upper surface, while those that are vertical have them in nearly equal numbers on both sides. Stomata are also found on the green shoots of plants, on the calyx, frequently on the under-surface of the corolla, sometimes on the upper, and also on the surface of some fruits. They are found on the upper surface only of floating leaves, and are entirely absent from submerged leaves, they having no true cuticle, but simply a coat of protein matter, which is termed the *epiblema*.[3] Stomata are also absent from cellular plants, with the exception of a modified form in *marchantia*. They are smaller and less numerous on succulent plants, and altogether absent from those succulent leaves that

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[1] Gr., *stoma*, a mouth. [2] Crescent-shaped; L., *luna*, the moon. [3] Gr., *epi*, upon; *blema*, a wound.

are developed underground, and also from the brown, scale-like leaves of some parasites or pseudo-parasites.

The Vascular System of the Leaf is divided into an upper and a lower portion, between which are the cambium cells. In the upper portion of the system are found the spiral vessels, woody fibre, and porous vessels; in the under portion are woody fibres and the laticiferous vessels. The vascular system is continuous with the axis, the upper portion with the wood, and the lower with the bark, or, more strictly, with the inner layer of the bark, the *endophleum.* The distribution of the vascular system, or *venation,* as it is termed, varies in different plants, and in different conditions of the same plant. A plant badly nourished will have a preponderance of the vascular system over the cellular in its leaves; as may be seen in the early spring in the leaves of the horse-radish, which are then much sub-divided; while later in the season, when growth is more rapid, more complete nourishment being obtained, the leaflets become entire, the spaces between the vascular ramifications becoming filled up with parenchyma. The vascular system is entirely wanting in the lower classes of plants; hence they are called *cellulares.*[1]

Venation.—The venation, or distribution of the vascular system in the leaves, has sufficient uniformity to render it applicable to the distinction of three large natural groups of plants, two of which are flowering plants, the third flowerless (*ferns*). In this flowerless group the venation is always forked, or *furcate,*[2] sometimes simply, sometimes repeatedly.

In the class of flowering plants called endogens, the veins are always parallel to each other, and connected by slight transverse veinlets, as in the *lily, grass,* and *maize.*

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[1] *Composed of cells.* [2] L., *furca,* a fork.

A group of plants of very inferior position, among the exogenous class of flowering plants, has a venation partaking of both the former groups—viz., the pine-tribe. True pines have the venation parallel, while in *Salsburia* and *Phyllocladus* the venation is furcate. In all other plants of the exogenous class the venation is *reticulated*,[1] or net-veined. In the pine-tribe is found the greatest diversity of leaf-form, governed in a great measure by the various modes of vascular distribution.

If the vascular bundles in the petiole are continuous through the centre of the leaf, gradually thinning out at the apex, the leaf is *unicostate*[2]—that is, one-ribbed. A great number of leaves are of this nature, as those of the *willow, oak, beech,* &c. The large primary vein is called the *mid-rib.*

In such leaves as the ivy, or the long-leaved plantain, where the petiole, as it joins the blade of the leaf, sub-divides its vascular bundles into several equal portions which diverge to the margin, the leaf is said to be *multicostate.*[3] If we use the word costa for these ribs, the smaller veins leading from them are termed the *primary veins.*

When a leaf is unicostate, and the primary veins run directly to the margin, the leaf is called feather-veined, as in the *sweet chesnut.*

Veins which issue from primary veins are distinguished as *secondary* when there is one ramification, and *curved* when there are more than one. The last branch, which always proceeds from the lower side of the vein, is usually curved, and united with the upper end of the vein beneath it. The greater the angular radiation of the veins, the broader is the leaf as a rule.

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[1] L., *reticulum*, a net. [2] L., *unus*, one; *costa*, a rib.
[3] L., *multus*, many; *costa*, a rib.

CHAPTER XIII.

LEAF CHARACTERISTICS.

Leaves differ in character, duration, texture, and form.

Character.—Differences of character are represented by—(1) the *true leaf;* (2) the imperfectly formed leaf, or *phyllodium;*[1] and (3) the *scale,* or rudimentary leaf.

Duration.—In duration leaves are either *deciduous*[2]—that is, they fall off at the end of the summer—or *persistent,* being so called when they remain for more than one season.

Texture.—In texture leaves are *fleshy, succulent, leathery,* or *thin.* If the veins are prolonged beyond the parenchyma of the leaf, and become indurated,[3] they are said to be *spiny,* as in the *holly.*

Form.—When the petiole is absent, leaves are said to be *sessile,* as in Fig. 3, Gr. x.; when it is present, they are *petiolate,* as in Fig. 1, Gr. x. They are *amplexicaul,*[4] or stem-clasping, when the sessile base of the blade clasps the stem horizontally, as in *Calceolaria amplexicaulis* (Fig. 3, Gr. x.) :—

Perfoliate,[5] when the base of the blade not only clasps the stem, but closes round it on the other side, so that the stem appears to pierce through the base of the leaf, as in *Chlora perfoliata* (Fig. 4, Gr. xi.) :—

Connate,[6] when two opposite sessile leaves have their bases united, so that the two leaves form one continuous organ circling the stem, as in the *teasel* (Fig. 12, Gr. ix.) :—

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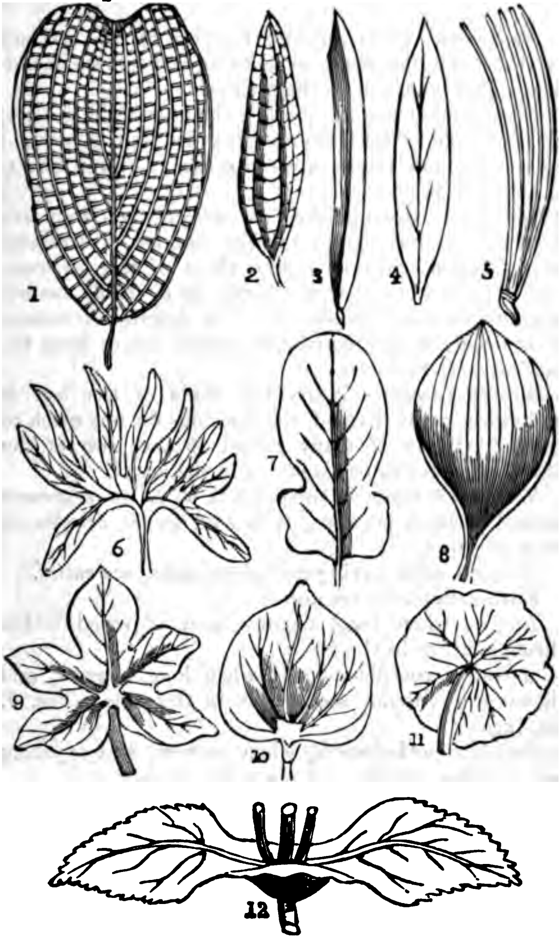
[1] Gr., *phullon,* a leaf, see p. 82. [2] L., *decido,* to fall of. [3] L., *induro,* to harden. [4] L., *amplexus,* embracing; *caulis,* a stem. [5] L., *per,* through; *folia,* a leaf. [6] L., *connatus,* connected.



GROUP IX.

1. *Lattice-leaf.*
2. *Lanceolate.*
3. *Ditto.*
4. Lanceolate.
5. Acicular.
6. Pedate.
7. Lyrate.
8. Ovate.
9. Palmate.
10. Obovate.
11. Orbicular.
12. Connate.

Decurrent,[1] when the two margins of the leaf are carried down the stem, so as to form narrow appendages called wings, as in the *thistles*.

Sheathing, or *vaginate*,[2] when the base of the petiole, or the whole of it, becomes expanded into a vertical cylinder round the stem, as in *grass*. (Fig. 4, Gr. x. a, *lamina ;* b, *vagina*.)

Leaves are distinguished as *radical* when they are developed near the ground in the manner of a rosette or tuft on a short axis, like those of the *primrose*, and *cauline* when they are borne on a visible ascending axis, like those of the *lily*. In descriptive botany it is usual to distinguish the radical leaves from the cauline or stem leaves.

Simple Leaves.—When the blade of the leaf is undivided, or, if divided, the divisions do not reach to the mid-rib, or if many ribbed to the base of the blade, it is said to be *simple*, as in the *laurel*.

When the blade is sub-divided, so as to represent several distinct portions, it is said to be *compound*, as in the *rose*.

Simple leaves, having no indentations, are *entire*.

Entire simple leaves are—

Linear, when long, narrow, and of equal width throughout, as in the *larch*.

Acicular[3] (needle-shaped), when long, narrow, and showing a circular section, as in the *pine*. (Fig. 5, Gr. ix.)

Subulate (awl-shaped), when narrow, and tapering from the base to the apex, as in the *juniper*.

Lanceolate (lance-shaped), when they are broadest below the middle, and tapering towards the apex, and three or more times as long as they are broad, as in the *ribbed plantain*. (Figs. 2, 3, 4, Gr. ix.)

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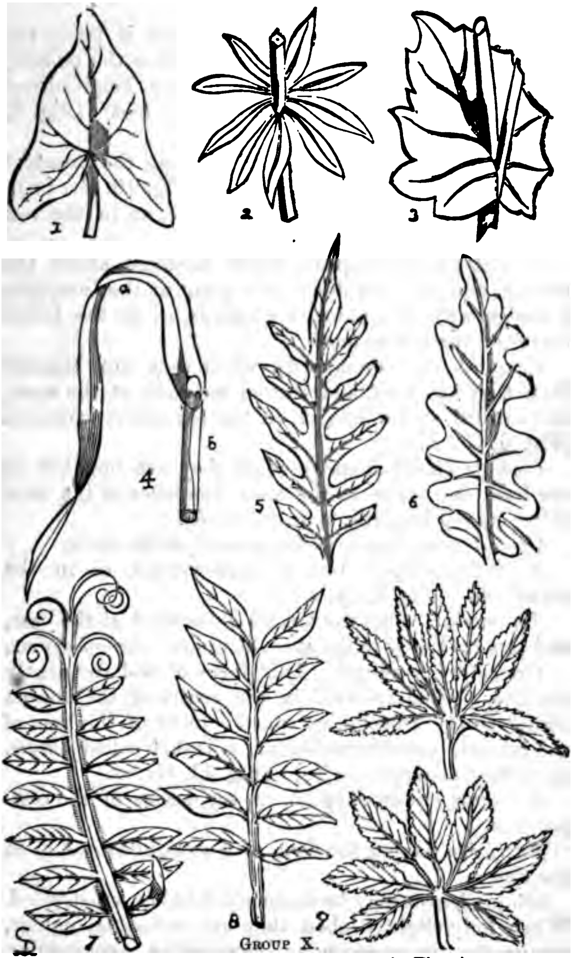
[1] L., *de*, down ; *curro*, to run. [2] L., *vagina*,, a sheath.
[3] *The following* terms are derived from the Latin. Their meanings are given in brackets.



GROUP X.

1. *Sagittate.*
2. *Verticellate.*
3. *Amplexicaul.*

4. Ligulate.
5. Pinnatifid.
6. Sub-pinnatifid.

7. Pinnate.
8. Ditto (abruptly).
9. Digitate.

Ovate (egg-shaped), when the length is twice the breadth, the greatest breadth being below the middle, such as would be represented by the longitudinal section of an egg, as in the *wayfaring tree.* (Fig. 8, Gr. ix.)

Obovate (reversely egg-shaped), having the broadest part at the apex, as in the *vetches.* (Fig. 10, Gr. ix.)

Elliptical, or broadest in the middle, as in the *red cornel.*

Cuneate (wedge-shaped), when broadest above the middle, and tapering down to a point at the base, like a wedge with the point downwards, as in the lower leaves of the *yellow bugle.*

Reniform (kidney-shaped), when they are broader than they are long, and curved outward at the apex, and inward at the base, as in the *sea-side convolvulus.* (Fig. 6, Gr. xi.)

Cordate (heart-shaped), when they are broadest at the base, and taper to the apex, the lobes at the base being curved inwards, as in the *violet.*

Obcordate (reversely heart-shaped), as in *clover.*

Sagittate, shaped like an arrow-head, as in the *caladium.* (Fig. 1, Gr. x.)

Triangular, when the lamina is broadest at the base, and tapers rapidly to the apex, as in some *chenopodiums.*

Orbicular, or round. This form of leaf frequently has the petiole inserted in the centre of the lamina owing to the auricles, or ear-like lobes of the base of the lamina, becoming coherent; it is then called *peltate*, as in the *tropæolum majus.* (Fig. 11, Gr. ix.)

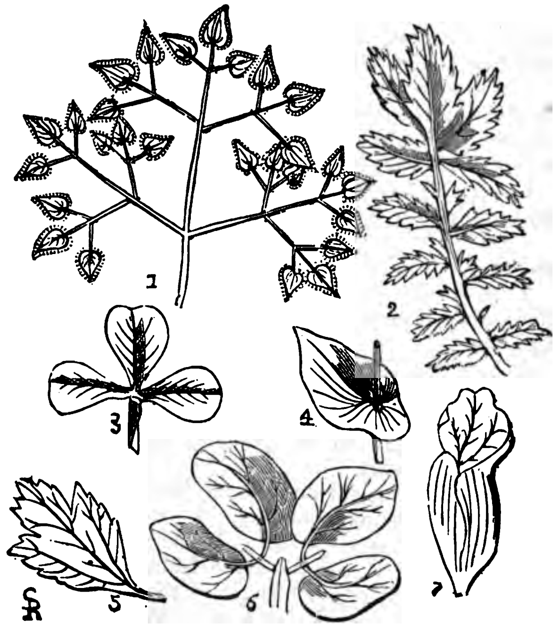
Spatulate (spoon-shaped), as the leaves of the *common daisy.*

Ensiform, having the form of a straight sword, as in the *flag.*

Simple leaves may be variously *lobed* or sub-divided. When only slightly lobed they are called triangular, tetrangular, quinquangular, hexangular, septangular,

&c., according as the lobes are three, four, five, six, seven, &c., in number.

When much divided they are *lobate*, as *bi*-lobate, *tri*-lobate, &c. When further divided, or deeper cleft, a



GROUP XI.

1. Tripinnate.
2. Pinnate.
3. Ternate.
4. Perfoliate.
5. Trifid.
6. Reniform leaves.
7. Leaf and phyllodium of *saracenia*. The leaf is the upper, veined portion.

five-lobed leaf is said to be *palmatifid*; if a three-lobed leaf, *trifid*.

A palmatifid leaf, with the two lower lobes again lobed, is called *pedate*, because it resembles the foot of a bird. (Fig. 6, Gr. ix.)

Compound Leaves.—When leaves are so much sub-divided that the parts can be separated without tearing the lamina, or fall away from each other at maturity, they are said to be *compound*, and the separate parts are called *leaflets*. The common stalk is the *petiole*, or *rachis*,[1] and the partial stalk supporting the leaflets is the *petiolule*.

The leaflets, or divisions of a leaf, usually have a similar circumscription to that of a simple leaf. The circumscription of a leaf is its general outline, all indentations being disregarded.

Compound leaves are *ternate* when composed of three separate leaflets, as in the *clover*. (Fig. 3, Gr. xi.)

Digitate,[2] when consisting of a number of elongated leaflets, as in the *horse-chesnut*. (Fig. 9, Gr. x.)

They may be *bi-* or *tri-*ternate, when twice or three times divided on the ternary plan, as in the *epimedium alpinum*.

When the leaflets are arranged on each side of the petiole, or rachis (the term rachis being limited to the portion from the apex whence the leaflets spring to), the leaf is said to be *pinnate*,[3] as in the *vetch*. (Figs. 7, 8, Gr. x.)

A simple leaf, sub-divided on this plan, but still having the lamina continuous, is called *pinnatifid*, as in the *hedge mustard*. (Fig. 5, Gr. x.)

Pinnate leaves may have the leaflets alternate, or opposite to each other. They are then distinguished as alternately or oppositely pinnate. When each leaflet is divided again in a pinnate manner the leaf is *bipinnate*, as in the *fumitory*. When again sub-divided it is *tripinnate*, as in the *small meadow rue*. (Fig. 1, Gr. xi.) When, by a further sub-division, it is not referable to either of these compounds, it is

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[1] *Gr., rachis*, a backbone. [2] L., *digitus*, a finger.
[3] *L., pinna*, a feather.

said to be *supra-decompound*, as the *carrot*. A leaf is *abruptly pinnate* when it terminates with a pair of leaflets, as in the *vetch*. (Fig. 8, Gr. x.) It is *unequally pinnate* when it terminates with a single leaflet.

The parts of a compound leaf are usually articulated, and they separate from each other at death.

The Apex.—The apex of a leaf is *acute* when it forms an acute angle, or tapers to a point, as in the *lilac*. (Fig. 3, Gr. x.)

Obtuse, when it forms a very obtuse angle, or when it is more or less rounded at the top, as in the *clover*. (Fig. 3, Gr. xi.)

Emarginate, or notched, when decidedly indented at the end of the mid-rib, as in *Acacia marginata*. (Fig. 1, Gr. ix.)

Truncate, when the end appears to be cut off square, as in the *tulip-tree*.

The Margin.—The margins of leaves, when free from indentations of any kind, are said to be *entire*, as in *tropæolum*. (Fig. 1, Gr. x.)

When the margin is raised so as to feel thicker than the lamina adjoining it, it is called *marginate*, as in *Acacia marginata*.

When indented like the teeth of a saw, it is *serrate*,[1] as in the *rose*.

When indented so that the teeth seem to be in pairs, a large tooth alternating with a smaller one, it is *bi-serrate*, as in some varieties of the *rose*.

Crenate,[2] with convex serrations, as in the *balm*.

Dentate,[3] with concave serrations, as in the *rocket*.

Acutely crenate, when the serrations are rectangular, like the teeth of a cross-cutting saw, as in *dwarf willow*.

Ciliate,[4] when bordered with thick hairs, or fine hair like teeth, as in the cross-leaved *heath*. (Fig. 1, Gr. xi.)

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[1] L., *serra*, a saw. [2] L., *crenatus*, crinkled. [3] L., *dentatus*, toothed. [4] Gr., *cilia*, hair.

Sinuate,[1] when the indentations are broad and irregular, but not deep, like those on a sea-coast, as in the *oak*.

Undulate, when the edges do not lie flat, but are bent up and down, resembling waves, as in the *Scotch kale*.

Lacinated, when the indentations are irregular, as in the *hawthorn*.

Spiny, when the teeth are elongated and hardened, as in the *holly* or *thistles*.

CHAPTER XIV.

APPENDAGES AND MODIFICATIONS OF THE LEAF.

Appendages. — The appendages of the leaf occur at the base of the petiole, or of the leaf when it is sessile. They are, in all cases, called *stipules*,[2] though some peculiar varieties possess special names.

The true nature of stipules is not satisfactorily determined; hence we cannot say what is the normal form and what are modifications.

Stipules occur nearly always in pairs, one on each side of the petiole. They occasionally, however, occupy an intermediate position between two opposite leaves, one on each side of the stem. Examples of the first may be seen in the *pea* and *pansy*, of the second in the *cinchona*. When only one stipule is developed, as in *azara*, it is probable that the other is aborted, and that two would be found if the plant were examined at an early stage.

Stipulary appendages at the base of the leaflets in compound leaves are called *stipels*.[2]

Stipules, when foliaceous, are usually developed

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[1] L., *sinus*, a bend. [2] L., *stipula*, a stalk.

GROUP XII.

1. Foliaceous stipules, and tendrils.
2. Tendril formed from petiole.
3. Ditto.
4. Spiny stipule and pulvinus of gooseberry.
5. *Stipule and tendril.*
6. Stipule (*ocrea*).
7. Spiny stipule.
8. Pitcher plant, showing the leaf above the ascidium, and on the left the phyllodium.
9. Stipules and tendril.

after leaves, as, indeed, their position would seem to necessitate; when membranous they are frequently the first developed portion of the leaf, and at certain seasons the only appendicular organs present, as in *rhubarb*. They are sometimes persistent throughout the whole life of the plant, as in the *pea;* and sometimes fall away very soon, as in the *oak*.

The chief varieties of stipules are the following:—

Leaf-like stipules, differing in nothing but position from true leaves, as in the *pea*. (Fig. 1, Gr. xii.)

Spiny, as in the *gooseberry*. (Figs. 4, 7, Gr. xii.)

Ocrea,[1] a membranous sheath, encircling the stem. (Fig. 6, Gr. xii.)

Tendrils, stipules developed into climbing branches. (Fig. 5, Gr. xii.)

Modifications.—The chief modifications of leaves occur in the petiole and stipules. The principal are:

1. *Tendrils*.—These are developed in those weak-stemmed plants which require support to maintain them in an erect attitude. They consist of thread-like processes, which twist round the supporting body, and enable the plant to climb. They are formed by the modification of various parts.

In the *pea* the extremity of the rachis and the two terminal leaflets are developed into tendrils. (Fig. 7, Gr. x., and Fig. 5, Gr. xii.)

In the *vine* the axis is modified into tendrils, and the same thing may be seen in the *Virginian creeper*.

In some cases the leaf becomes modified into a tendril, as in *corydalis*. (Fig. 2, Gr. xii.)

The petiole may twist and perform the functions of a tendril, as in *clematis*. (Fig. 3, Gr. xii.)

2. *Phyllodium*.[2]—When the petiole becomes foliaceous, or leaf-like, it is called a phyllodium, as may be seen in the *orange*, or more plainly in the so-called leaves of the *goat's beard*.

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[1] *L., ocrea*, a legging. [2] Gr., phullon, a leaf.

3. *Ascidium.*[1]—Sometimes the margins of the leaves of a phyllodium become united, and a hollow vessel is thus formed. This peculiar variety is called an *ascidium*, and is found in the *pitcher-plants* (*Neponthes*), Fig. 7, Gr. xi., and Fig. 8, Gr. xii., where an ordinary phyllodium is also seen to be developed.

CHAPTER XV.

PHYLLOTAXIS.

The arrangement of leaves about the axis has been the subject of much attention among modern botanists, and although, perhaps, rather above the requirements of an elementary student, it may be of advantage to the reader to obtain some knowledge of the principles of *phyllotaxis*,[2] as this branch of botany is called.

It will be readily perceived, even by the most casual observer, that leaves are either *alternate*, *opposite*, or *verticillate* in their arrangement. The late Dr. Lindley considered the alternate arrangements the normal one, and the opposite and verticillate arrangements as abnormal, occasioned by the suppression or shortening of the internode, and the confluence of the nodes. Plants whose natural habit is to have the leaves alternate, sometimes have them opposite, or approximating in pairs; while plants whose natural habit is to have the leaves opposite, occasionally produce them alternately. Some opposite-leaved plants also occasionally produce their leaves in verticils of three or even four, as in the *fuchsia*. In the *rhododendron* cultivated in our shrubberies, we see alternate leaves approximating into verticils as the axis ceases to elongate.

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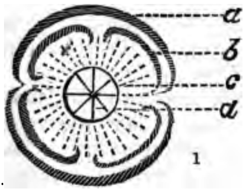
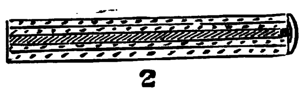
[1] Gr., *askidion*, a bottle. [2] Gr., phullon, leaf; taxis, order.

It will be observed in the germination of seeds that the arrangement of the seed-leaves is of three different kinds. Endogens, usually having one seed-leaf, sometimes have a second smaller one, which is always alternate with the first, all the leaves developed afterwards being alternate, as far as the vegetative axis is concerned. In the floral region a fresh arrangement takes place in most plants.

Exogens, on the contrary, have the seed-leaves always opposite to each other, the succeeding leaves being often alternate.

In gymnogens, or coniferous plants, a verticillate arrangement is prevalent in the seed-leaves, and an alternate one in succeeding leaves.





GROUP XIII.

1. Phyllotaxis of the flower of the Poppy :—*a*, calyx; *b*, corolla; *c*, stamens; *d*, carpels. The stamens are about two hundred in number, and are arranged in four rows of fifty each. They approximate to a spiral arrangement.

2. Vertical section of Scotch Fir, showing the medulla and two concentric rings with spirally-arranged minute knots, produced by the leaf-like branches of the tree. From a specimen in the Museum at Kew.

Opposite leaves are usually developed in pairs at right angles to each other, so that the first and third, and second and fourth pairs are perpendicular to each other; these are termed *decussate*.[1] Examples are found in the *mint* tribe.

If a line be drawn from the base of one leaf (when the

[1] L., *decusso*, to divide diagonally.

leaves are alternate) to the base of the next, a spiral will be described upon the axis. Hence it is inferred that the spiral is the typical arrangement of leaves, the angle of the spiral varying in different plants. Alternate leaves may sometimes present the appearance of two, three, or more rows down different sides of the stem. When they form two rows on opposite sides of the stem, so that the third leaf is over the first, and the fourth over the second, the arrangement is called *distichous*,[1] and is represented by the fraction $\frac{1}{2}$, signifying that one turn of the spiral *two leaves* are encountered. The *lime*-tree is a familiar example.

When, in *one turn* of the spiral, *three leaves* are encountered, as in the *sedge*, the arrangement is termed *tristichous*, and is represented by the fraction $\frac{1}{3}$.

That arrangement by which *three leaves* are encountered in *two turns* of the spiral, as in the *oak*, and is represented by $\frac{2}{5}$.

Other arrangements are common, such as $\frac{3}{8}$ in the *laurel*; $\frac{5}{13}$ in the *house-leek*; $\frac{8}{21}$ in the *plantain*; $\frac{13}{34}$ in some other plants. In some of the cactus tribe, such as *mammalaria*, *melocactus*, and *echinocactus*, the arrangement becomes much more complicated.

In many herbaceous plants, with a depressed or shortened axis, and with sheathing bases to the petioles, it is difficult to ascertain the arrangement; but at some time or other there is usually an elongated axis that can be studied, even if it be only the axis bearing the flowers.

In the poppy we find an opposite arrangement in the seed-leaves, an alternate arrangement in the leaves that follow the seed-leaves, an opposite arrangement in the calyx, a verticillate arrangement in the corolla, and an intricate spiral arrangement in the stamens,

[1] Gr., *dis*, turn; *stichos*, rank.

with a final verticillate arrangement in the carpels. (Fig. 1, Gr. xiii.)

The most striking example of spiral arrangement is perceptible in the pine tribe, more especially in the scale-like leaves of the cones. The leaf-like branches of the genus *pinus* are arranged with the same regularity and accuracy, and a section made vertically through the centre of the axis of many of the species will show small knots, arranged in a spiral manner according to the insertion of the branches. (Fig. 2, Gr. xiii.) These are only perceptible in the two or three concentric rings adjacent to the medulla, corresponding to the duration in time of the leaves on the stem.

CHAPTER XVI

THE INFLORESCENCE, &c.

Description.—The root, stem, and leaves have for their function the maintenance of life in the individual plant. They are, therefore, *sustentative* organs.

An equally important set of organs is designed for the maintenance of the *species*. These are the *reproductive* organs.

The essentials of reproduction are the *pollen*, and the *ovule*, in flowering plants; *spores*, and analogous bodies, in flowerless plants.

These bodies do not, however, appear by themselves, but are developed in and protected by certain other parts of the plant—as, for example, the pollen in stamens, the ovule in the ovary—while both are surrounded by certain modified leaves called *petals* and *sepals*. The whole assemblage of ovary, stamens, petals, and sepals is called the *flower*. The axis upon which the flowers are borne is called the *inflorescence*.[1]

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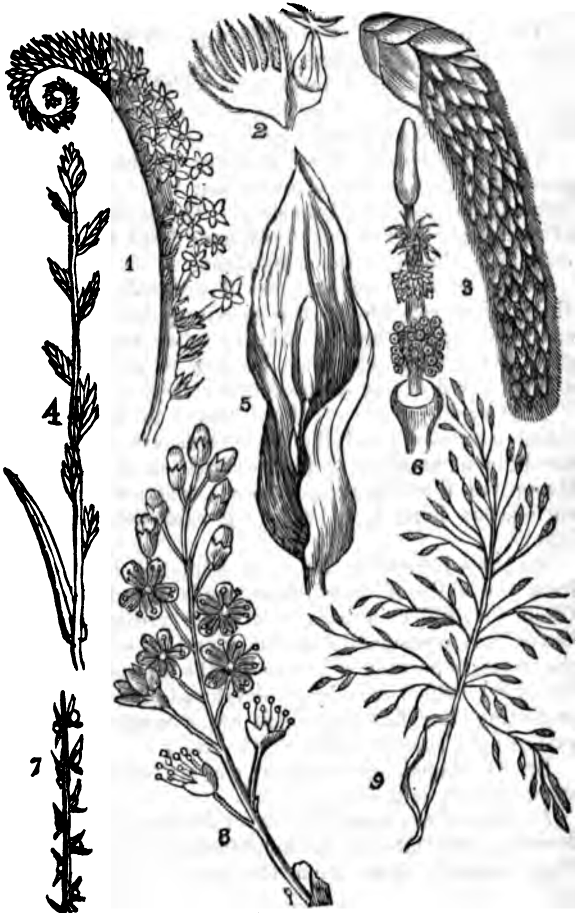
[1] L., *infloresco*, to begin to bloom.



GROUP XIV.

1. Cyme (Scorpioid).
2. Single flower of Amentum.
3. *Amentum.*
4. Locustæ.
5. Spathe.
6. Spadix.
7. Spike.
8. Raceme.
9. Panicle.

The reproduction of flowerless plants will be considered in future chapters.

Flower-buds.—The buds from which flowers are formed are developed in the axils of certain leaves called *bracts*, except in the *cabbage-tribe.*

Flower-buds differ from ordinary leaf-buds in not possessing that power of expansion which causes the latter to develop into branches. The growing-point of a flower-bud remains fixed, and floral leaves are developed almost on the same plane.

Under certain circumstances flower-buds revert to their foliar condition; the growing-point becoming extended, and a branch bearing foliar leaves being produced. This may often be seen in *roses*, and in a less marked degree in the *double cherry.*

The arrangement of floral leaves in the bud is called *æstivation*[1], and the same terms are applied to the different varieties, as in the vernation of leaf-buds. Group viii. illustrates the forms of vernation and æstivation, but Figs. 1, 9, 12, belong exclusively to the latter.

Bracts.—Bracts,[2] as we have seen, are the leaves from the axils of which flower-buds are developed. Often they differ in no respect from ordinary foliar leaves, but occasionally modifications arise. One of the most important of these is the *spathe* (Fig. 5, Gr. xiv.), which is a bract developed into a sheath protecting the flowers, which are arranged on an axis called a *spadix.* (Fig. 6, Gr. xiv.)

Bracts, though generally green, are sometimes of other colours, as in *bougainvillea.*

Bracteoles,[3] are bract-like leaves developed upon the flowering axis, often immediately beneath the flowers. They generally differ from the bracts in shape, and

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[1] *L. æstivus*, summer. [2] L. *bractea*, a thin leaf. [3] L., *bracteolus*, a little bract.

are sometimes mere scales. When a number of bracteoles are arranged in a verticil they are called an *involucre*. Examples of this are seen in the *daisy*, and many other plants.

Buds are occasionally developed from the axils of bracteoles, but this is very unusual, and generally the effect of some abnormal condition of the plant. The variety known as the *hen-and-chicken da sy* is an example of this development, the little heads of flowers being produced from buds in the axils of the bracteoles.

The Inflorescence is an axis, branched or simple, the whole of whose buds are flower-buds. (*Schleiden.*)

It is entirely destitute of leaves, or has only imperfect foliaceous organs, termed *bracts;* and is terminal or axillary in development, bearing a solitary flower or an indefinite number of flowers.

That part of the axis proceeding immediately from the stem is termed the *peduncle*[1] ; when branched, each stalk supporting a solitary flower is termed a *pedicel.* (Fig. 8, Gr. xv.) If the flower-stalk is not developed, and the flower is consequently attached directly to the axis, it is said to be *sessile ;* if stalked, *pedicillate.*

If the inflorescence is the only axis that rises above the ground, as in the *hyacinth, cowslip,* &c., it is called a *scape.*[2] (Fig. 6, Gr. xv.)

The forms of inflorescence may be studied in two sections, those that are simple and those that are branched.

Simple Forms of Inflorescence.—These include all flowers that are sessile.

Spike, an axis more or less elongated and cylindrical, whose flowers are sessile, as in the *plantain.* (Fig. 7, Gr. xiv.)

Amentum,[3] or *Catkin,* an inflorescence that withers

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[1] L., *pes*, a foot. [2] L., *scapus*, a stem. [3] L., *amentum*, a strap.

and falls off immediately after flowering. It differs from the spike only in being deciduous, as in the *willow*. (Fig. 3, Gr. xi.)

Cone, an inflorescence densely crowded with female flowers or naked ovules, borne in the axils of bracts which are coriaceous, woody, or membranaceous, as in the *spruce, pine, hop.*

Capitulum,[1] an inflorescence the axis of which ceases to grow in length, but expands laterally, becoming convex or discoid, as in the *sunflower*, *daisy*, &c. (Fig. 2, Gr. xiii.)

Hypanthodium,[2] an inflorescence in which the apex of the axis is arrested in development, while the circumference continues to grow upwards, eventually enclosing, or partly enclosing the flowers, as in the *fig*. (Fig. 1, Gr. xv.)

Spadix,[3] an inflorescence whose axis is succulent, and bears a large sheathing bract (spathe) at the base. It may be either simple or branched, as in the *Arum*, *palms*, &c. (Figs. 5, 6, Gr. xiv.)

Branched Forms of Inflorescence.—*Raceme*,[4] an inflorescence with one branch, the pedicels of which are of equal length, as the *laburnum*. (Fig. 8, Gr. xiv.)

Corymb,[5] an inflorescence differing from the raceme in that the pedicels of the lower flower become longer than those of the upper, so that the flowers appear all on the same level. When these pedicels are again branched the corymb is termed compound. This form is sometimes called a *fascicle*. Examples are found in the *cuckoo flower* and *sweet William*. (Fig. 3, Gr. xvi.)

Panicle,[6] an inflorescence differing from the raceme in being more compound, the pedicels being again branched, as in *oats*. (Fig. 9, Gr. xiv.)

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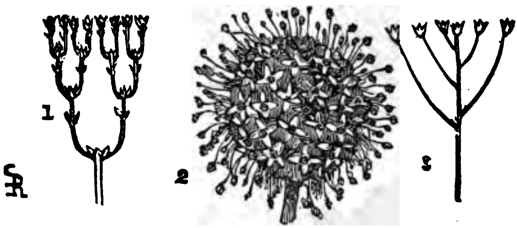
[1] L. *capitulum*, a little head. [2] Gr., *anthos*, a flower.
[3] L., *spadix*, a broken palm-branch. [4] L., *racemus*, a bunch.
[5] L., *corymbus*, a cluster. [6] L., *panicula*, a tuft.

GROUP XV.

1. Hypanthodium.
2. *Cyme.*
3. Simple umbel.
4. Compound corymb.
5. Compound umbel.
6. Scape.

Cyme,[1] an inflorescence differing from the panicle in the non-development of the axis in an upward direction, while it is continued laterally and apparently irregularly, so that all the flowers are brought to the same level. When the order of expansion of the flowers is from the circumference to the centre, the cyme is called *centripetal,*[2] as may be seen in the *elder.* When the basal or central flowers expand first, as in the *stitchwort,* the cyme is *centrifugal.*[3] If the lateral axis is developed on one side of the basal flower only, and follows the same law in the succeeding flowers as in *forget-me-not,* the cyme is termed *scorpioid.* (Figs. 1, Gr. xiv.; 2, Gr. xv.; and 1, Gr. xvi.)

Umbel,[4] an inflorescence in which all the flowers are supported on pedicels of equal length produced from



GROUP XVI.

1. Dichotomous Cyme. | 2. Capitulum. | 3. Corymb.

the same plane of the axis, and spreading out like radii, as in the *ivy.*

If each pedicel of an umbel produce a secondary umbel, the inflorescence is termed a *compound umbel;* the entire inflorescence being termed the universal umbel, while the secondary umbels are termed partial

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[1] Gr., *kuma,* a wave. [2] L., *centripeto,* to fly to the centre. [3] L., *centrifugo,* to fly from the centre. [4] L., *umbella,* an umbrella.

umbels. An example is found in the *fennel*. (Fig. 5, Gr. xii.)

Glomerulus,[1] an inflorescence consisting of clusters of flowers without pedicels, and surrounded by bracts (*involucra*) seated on a common axis of a globular form. Theoretically the glomerulus is a compound umbel, with the pedicels and radii not developed. The *globe thistle* is an example.

Locusta,[2] an inflorescence in which a number of small spikelets are seated on a common axis, as in *wheat*. (Fig. 4, Gr. xii.)

The development of the different forms of inflorescence is more readily understood when they are studied in their relation to each other.

CHAPTER XVII.

THE FLOWER.

Having considered the nature of foliar leaves as organs of nutrition, we now proceed to describe their modified condition as organs of reproduction.

The Flower is a collection of organs destined to bring about the reproduction of the species. It consists of several whorls,[3] or series of floral leaves, usually four, but subject to variation in this respect, either by non-development or by multiplication.

The *first*, or external series, is the *calyx*,[4] whose individual leaves are called *sepals*,[5] or *calycine leaves*. All organs external to this, and situated between the leaves, properly so called, and the calycine leaves,

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[1] L., *glomerulus*, a little ball. [2] L., *locus*, a place. [3] A whorl is an arrangement in a ring. [4] L., *calyx*, a cup. [5] L., *sepio*, to enclose.

are termed *bracts;* but in some instances the calyx series is multiplied, and the outer series is then called an *epicalyx.*[1]

The usual colour of the calyx is green, but there are numerous examples of calyxes, and also of bracts of various other colours.

The *second* series of floral organs is the *corolla,*[2] the individual leaves of which are called *petals*, or *corolline leaves.* The corolla is usually larger than the calyx, and variously coloured, very rarely green, and is mostly deciduous. This series is often multiplied; and is sometimes partially, at others wholly abortive. If only one series of floral envelopes is developed, whether it be coloured or not, it is called the calyx.

Among endogens it is common for the calyx and the corolla to be indistinguishable from each other when expanded; the two series are then collectively called the *perianth.*[3]

A series, termed a *corona,*[4] interior to the perianth, is also developed in some flowers. Its origin is not yet determined. The individuals of this series are united at the margins, and the whole is generally in the form of a cup, tube, or bell; and, as it occasionally bears anthers, it is usually considered an accessory series of stamens.

The *third* series in the order of development in a perfect flower is the *andrœcium,*[5] composed of the *stamens,*[6] which are interior to the corolla. The number of stamens is multiplied in several ways, as we shall demonstrate in the chapter devoted to them. They constitute the male system, or male organ, as some think proper to call it, of phænogamous, or flowering plants. They are, therefore, essential to a flower,

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[1] Gr., *epi*, upon, *calyx.* [2] L., *corolla*, a little crown.
[3] Gr., *peri*, about; *anthos*, a flower. [4] L., *corona*, a crown.
[5] Gr., *andros*, male. [6] L., *stamen*, a thread.

whereas the calyx and corolla are non-essential; that is, the latter need not be present to ensure reproduction.

As before stated, the individual stamens are subject to multiplication. They are also subject to abortion. An instance occurs where only half an anther is developed to perform the functions of the male system. Multiplication and abortion sometimes take place simultaneously, as is instanced in what florists call double flowers, where the parts of this third series are multiplied, but anthers are aborted, and the filament, or the whole staminal leaf, becomes petaloid.

The *fourth* and last series, occupying the centre of the flower, is the *pistil*[1] or *gynæcium*,[2] the individuals of which are called *carpels*.[3] This is the female organ of the flower, and consists of modified leaves (carpellary leaves) folded inwards, and united by their margins, along which are developed the bodies destined to become seeds.

The carpellary leaves seldom agree in number with those of the floral envelopes. They are usually fewer, but are occasionally multiplied, as may be seen in the *columbine*, where a double series of carpels is frequently developed. In full flowers the carpels disappear entirely; they are either not developed, or, if produced, they are in the form of petals, or even ordinary foliar leaves.

The Calyx.—*Description.*—The first or external series of the floral leaves is the calyx, the individual leaves of which are called *sepals*, and are either separate and free (*polysepalous*[4]), or cohere together (*gamosepalous*[5]). They are either of a green colour, like the leaves (*foliaceous*) or coloured in a bright

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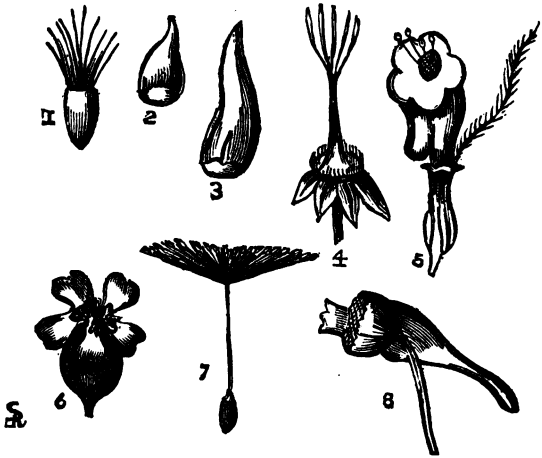
[1] L., *pistillum*, a pestle. [2] Gr., *gune*, a pistil. [3] Gr., *karpos*, fruit. [4] Gr., *poly*, many, *sepala*. [5] Gr., *gamos*, united.

manner (*petaloid*). The calyx either falls off immediately after the expansion of the flower (*deciduous*), or it remains till the maturity of the fruit, and even later (*persistent*). In many plants it continues to grow long after the corolla and the stamens have disappeared, as may be observed in the *mint* family.



GROUP XVII.

1. Pappus.
2. Operculate.
3. Calyptrate.
4. Reflexed calyx of mallow.
5. Calyx of *valerian*, showing feathery limb.
6. Inflated.
7. Pappus.
8. Calcarate.

Number of Sepals.—The number of sepals in the calyx usually governs the number of organs in the succeeding whorl of the flower. These numbers are in exogens usually fives or fours or their multiples, and in endogens threes or sixes, or powers of three.

Epicalyx.—In some malvaceous and some rosaceous plants there is a second calyx, as it were, the parts of which alternate with those of the other: this is termed an *epicalyx.*

Cohesion.—A gamosepalous calyx consists of the

united portions called the *tube*, and a free portion or the *limb*, the parts or divisions of which may be either lobes, teeth, or bristles. The tube is also sometimes prolonged at the base into a spur. The calyx is then termed *calcarate*,[1] as in *tropæolum*(Fig. 8, Gr. xvii.), or an individual sepal may attain the same condition, as in *larkspur*. A hood-like process is sometimes developed on the calyx tube. This is an appendix, and the calyx is called *appendiculate*, as in *skull-cap*.

In some *myrtaceous* plants, such as the Australian gum-trees, the cohesion of the sepals is entire along their whole margin, and the calyx falls off in one piece by the rupturing of the base. This condition is termed *operculate*.[2] (Fig. 2, Gr. xvii.)

In the *escholtzia* of the gardens a similar condition obtains, except that the cohesion is incomplete on one side. This is termed *calyptrate*.[3] (Fig. 3, Gr. xvii.)

Adhesion.—Having pointed out the cohesion of the sepals in some calyces, we now proceed to speak of another kind of union of parts that occurs in flowers. Cohesion is the joining together of *similar* parts; but we find very numerous families of flowers in which there is a union of *dissimilar* parts, even of portions of each of the series constituting the flower. This is termed *adhesion*. When the calyx is adherent to the ovary by the tube, the limb, or free portion, will be on the top of the ovary. The calyx is then termed *superior*. (Fig. 5, Gr. xvii.) When it is not adherent, but free, it is *inferior*. (Fig. 4, Gr. xvii.) In composite flowers, and in flowers that are crowded together in dense masses, the superior calyx is subject to much abortion, being sometimes indicated only by a thickened ring or a few teeth, or by a collection of bristles or hairs. These latter

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[1] L., *calcar*, a spur. [2] L., *operculum*, a lid. [3] Gr., *kaluptra*, a covering.

free portions of the calyx are in composite flowers developed wholly or in part after the flowers have withered, and serve as appendages to disperse the seed when ripe, and receive the name of *pappus*. (Figs. 1, 7, Gr. xvii.) Many other varieties of adhesion occur, which need not be here described.

If the calyx is the only floral envelope enclosing the essential organs, the flowers are *monochlamydeous*,[1] as in the *Marvel of Peru*.

The Corolla.—*Description.*—The second or inner whorl of floral leaves is the corolla, which, when expanded, is usually larger than the calyx, more brightly coloured and attractive, and frequently has a different scent from other portions of the plant. The individual coralline leaves termed petals are usually developed alternately with the sepals of the calyx. When the series is multiplied, the second series of floral leaves is alternate with the first, and opposite to the sepals.

In some instances where the series of floral envelopes is multiplied, the resemblance between the calyx and the corolla is so close that it is difficult to distinguish them. This occurs in the *white water-lily* and some *magnolias*. Attention must then be paid to the position of the parts, rather than to their colour and texture.

Cohesion.—Petals are subject to the same laws of cohesion as sepals, and when coherent the corolla is termed *gamopetalous*. When, on the contrary, there is no cohesion and the petals are free, the corolla is *polypetalous*, the parts falling off separately, whereas a gamopetalous corolla falls off entire. When the corolla is adherent to another organ it is generally persistent.

Forms of Petals.—Petals may be stalked, as in

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[1] *Gr., monos*, one; *chlamus*, a garment.

GROUP XVIII.

1. Calceolate.
2. Personate.
3. Ligulate.
4. *Tubular.*
5. *Tubular.*
6. *Labiate.*
7. *Campanulate.*
8. Ringent.
9. Irregular polypetalous flowers.
10. Rotate.
11. Perianth of epipactis.
12. Hyprocateriform.
13. Papilionaceous.
14. Irregular flower of *larkspur*.
15. Infundibuliform.
16. Irregular flower of Iberis.
18. Flower of grass.
19. Urceolate.

the *pink*. The stalk is termed the *claw* or *unguis*, and the petal is said to be *unguiculate*. The expanded portion is the *blade* or *lamina*. When the stalks are coherent or joined together, a tube is formed, the opening into which is termed the *faux*.[1] The free portion of the complete corolla is then the lamina, and the divisions, the lobes.

When petals are not prolonged at the base into an unguis, they are said to be sessile, as in the *rose*. Petals are sometimes prolonged near the base into a hollow tube or spur; they are then termed *calcarate*,[2] as in the *columbine*. Garden varieties of this are very common, in which the corolline whorls are multiplied several times, the spurs of the second series growing into the spurs of the first, and those of the third into those of the second, and so on; so that in looking at the flower carelessly the five spurs of the first series are all that is observed.

Petals are either entire, lobed, toothed, or fringed, and sometimes much divided. The same terms are used in describing the forms of petals as those used in describing simple leaves. No instance occurs of compound petals.

Appendages known as *fornices*[3] are sometimes attached to them, as in *lychnis*. Their origin is doubtful.

Forms of Corolla.—When all the petals of a flower are of equal size and shape, the flower is said to be *regular*.

When the petals are of different forms and sizes, so that when divided across the halves are dissimilar, the flower is *irregular*.

When all the floral whorls agree in number, and are developed in the normal alternating manner, the flower is *symmetrical*.

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[1] L., *faucis*, the throat. [2] L., *calcar*, a spur. [3] L., *fornix*, an arched opening.

When the parts of one floral whorl do not agree with those of the next in number or position, they are *non-symmetrical.* Examples of regular polypetalous corollas are the *buttercup* and the *rose;* of irregular polypetalous corollas, the *pea* family and the *milkwort;* of regular gamopetalous corollas, the *bindweed* and the *primrose;* of irregular gamopetalous corollas, the *antirrhinum* and the *dead-nettle;* of symmetrical flowers, the *geraniums;* of unsymmetrical flowers, the *primrose*, where the stamens are developed opposite to the petals instead of alternate with them.

The forms and parts of irregular flowers are distinguished by different names, as they have been fancied to resemble other more or less common objects. The flowers of the pea are termed *papilionaceous,*[1] butterfly-shaped; and the three different forms of the petals are distinguished separately. The upper and larger petal is the *vexillum*[2] or *standard.* The two side petals are the *alæ*[3] or wings, and the two lower, which are usually more or less coherent along one margin, are termed the *carina,*[4] or keel. (Fig. 13, Gr. xv.)

In other flowers the limb is developed in a vertical direction. Such are termed *labiate,*[5] or lipped. The upper lip is sometimes distinguished again as the *galea,* or helmet, and the lower as the *labellum.* (Fig. 6, Gr. xviii.) If the upper and lower lips are apart and open (Fig. 8, Gr. xviii.) the corolla is said to be *ringent* (grinning), as in the *dead-nettle.* When the two lips are in contact or closed, the corolla is termed *personate*[6] (masked), as in the *antirrhinum.* (Fig. 2, Gr. xviii.) When the lips are hollowed out or inflated, they are termed *calceolate*[7] (slippered), as in the

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[1] L., *papilio,* a butterfly. [2] L., a standard. [3] L., wings. [4] L., a keel. [5] L., *labium,* a lip. [6] L., *persona,* a mask. [7] L., *calceolus,* a small shoe.

calceolaria. (Fig. 1, Gr. xviii.) These labiate forms of the corolla are assumed to be caused by the absorption of a contiguous organ, the rudiments of which may often be traced. Occasionally the absorbed organ is developed in its proper place, and the corolla becomes regular.

A form of irregular gamopetalous corolla is also common to many composite flowers. In those forms of inflorescence in which the flowers are collected together into capituli, so that the head of flowers resembles a single flower, the individual flowers are termed *florets,* and are frequently of two forms in the same head, those of the centre or disc being regular and tubular in form, and those of the circumference or ray being irregular and strap-shaped (*ligulate*[1]). This irregularity in the ray-florets is due to a partial want of cohesion. The five petals of the florets are united by all their margins in those that are tubular, while two margins are free in those that are ligulate. This is probably due to crowding and pressure during the early stages of development. (Fig. 3, Gr. xviii., represents a ray-floret of a daisy.)

A similar irregularity occurs in some polypetalous corollas where the flowers are collected together in dense heads, as may be seen in many umbelliferous flowers, and some cruciform, as in *candy-tuft,* where the outer petals are larger than the inner.

According to the different degrees of expansion of various parts of the flower they assume various forms, a few of which are here enumerated for the assistance of the student.

Of *Gamopetalous Corollas* there are the *campanulate,*[2] or bell-shaped, as in the *harebell.* (Fig. 7, Gr. xviii.)

The *infundibuliform,*[3] or funnel-shaped, as in the *convolvolus.* (Fig. 15, Gr. xviii.)

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[1] L., *ligula,* a strap. [2] L., *campanula,* a little bell.
[3] L., *infundibulum,* a funnel.

The *hypocrateriform*,[1] as in the *primrose*. (Fig. 12, Gr. xviii.)

The *tubular*, as in the *thistle*. (Fig. 5, Gr. xviii.)

The *urceolate*,[2] or urn-shaped, as in many of the *heaths*. (Fig. 19, Gr. xviii.)

The rotate, or wheel-shaped, as in the *forget-me-not*. (Fig. 10, Gr. xv.)

Of *polypetalous corollas*. Where the claws suddenly dilate into a limb, we have the *caryophyllaceous* corolla, as in most of the *pink* family; where the claws gradually dilate into a limb, the *foliaceous* corolla, as in the *geranium*.

Where four petals are placed opposite to each other in the form of a cross, the *cruciform* corolla prevails, as in the *stock* and *wallflower*.

Where there is no claw, or where it is so small as to be indistinguishable, we have the *rosaceous* corolla, as in the *rose*.

Nectaries.—At the base of the petals in some flowers are formed small cavities, which secrete honey, as in some *buttercups*; these are termed *nectaries*, and no doubt assist the function of the essential organs by attracting insects, by whose agency the pollen is chiefly distributed.

Flowers possessing calyx and corolla are termed *dichlamydeous*.[3] Flowers with abortive petals occasionally occur, however, among dichlamydeous groups; these should always be studied by the light derived from an examination of the structure of allied species.

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[1] Gr., *krater*, a cup. [2] L., *urceolus*, a little pitcher.
[3] Gr., *di*, two; *chlamys*, a garment.

CHAPTER XVIII.

THE FLOWER—(continued).

THE STAMENS OR ANDRŒCIUM.

Description.—The third series or whorl of floral leaves is formed of the *stamens*, and is called the *andrœcium*. A stamen, when perfect, consists of a *filament*, or stalk, and an *anther*, or head. The latter alone is essential, the former being sometimes absent. (Figs. 9 to 12, Gr. xx.)

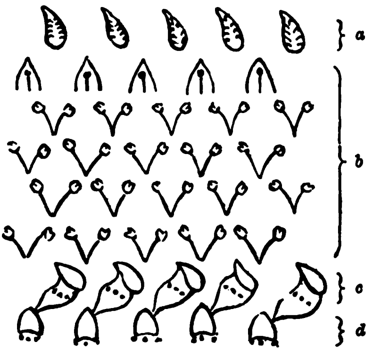
Stamens are usually developed alternately with the petals, and opposite to the sepals. Occasionally they are developed opposite to the petals, and alternate with the sepals, as may be seen in the primrose. The cause of this will be alluded to presently.

The number of stamens in a flower is either the same as the number of the petals or a multiple of that number, with occasional aberrations, which can only be explained by reference to the higher branches of botanical science. When the stamens are double or triple the number of the petals, the several series alternate with each other, and frequently they are of diminished length in each succeeding whorl. The number of stamens in a flower is usually indicated by a Greek numeral prefixed to the word "androus," which signifies male.

One Stamen is	**Monandrous.**		**Seven Stamens are**	**Heptandrous.**	
Two Stamens are	**Di-**	**"**	**Eight "**	**Oct-**	**"**
Three "	**Tri-**	**"**	**Nine "**	**Enne-**	**"**
Four "	**Tetra-**	**"**	**Ten "**	**Dec-**	**"**
Five "	**Pent-**	**"**	**Twelve "**	**Dodec-**	**"**
Six "	**Hex-**	**"**	**" to Twenty "**	**Icoso-**	**"**

Above twenty they are said to be indefinite, and are indicated by the sign ∞. Indefinite stamens do not always have the regular leaf-like arrangement on the axis, as the accompanying diagram of the receptacle of

the columbine will illustrate. It will be seen that the stamens alternate in pairs, while in the last series they are developed singly. The number of vascular bundles connecting the organs with the receptacle probably governs this arrangement. It will be seen there are three scars where the sepals have separated from the axis, and also three where the petals were placed. In all probability only two vascular bundles are connected with each pair of stamens, and one only with each stamen of the last series. Accompanying each of the



GROUP XIX.

Receptacle of columbine—*a*, carpels; *b*, stamens; *c*, petals; *d*, sepals.

last stamens is a membranous scale that seems almost structureless. In finely developed flowers the first series of stamens may sometimes have three individuals in each place. The conclusion to be drawn from this arrangement is that the stamenal leaf may sometimes be sub-divided so as to produce several stamens.

This points to the more striking arrangement of the stamens in *hypericum*, where we find five sepals, five petals with an indefinite number of stamens arranged in five or three bundles, each bundle being united at

the base, and occupying the position usually assigned to one individual stamen. Several similar or analogous arrangements might be cited in the rosaceæ, but the examples already given are deemed sufficient to impart to the student some idea of the nature of stamens.

Position.—Stamens developed free, having neither cohesion nor adhesion, are termed *hypogynous*,[1] *i.e.*, under the pistil, as in the *poppy*. (Figs. 13, 14, Gr. xx.)

When they are adherent to the calyx they are *perigynous*,[2] as in the *hawthorn*. (Fig. 16, Gr. xx.)

When adherent to the corolla they are *epipetalous*,[3] as in the *campanula*. (Fig. 17, Gr. xx.)

When they appear to be adherent to the ovary, they are *epigynous*, as in the *carrot*. (Fig. 16, Gr. xx.)

When the stamens and the pistil are adherent to each other, so that they appear combined together in one column, they are termed *gynandrous*.[4]

When any number of stamens cohere together they are said to be *monadelphous*.[5] (Figs. 1, 5, Gr. xx.)

When two separate bundles occur in the same flower, they are *diadelphous*,[6] as in the *pea*. (Fig. 7, Gr. xx.)

When there are three or more present, they are *polyadelphous*,[7] as in *St. John's wort*. (Fig. 2, Gr. xx.)

When of six stamens in a flower two are longer than the other four, they are *tetradynamous*,[8] as in the cabbage tribe. (Fig. 6, Gr. xx.)

When of four, two are longer than the other two, they are *didynamous*, as in the *mint tribe*. (Fig. 9, Gr. xx.)

When a whorl of stamens is coherent together by the anthers only, the stalks being free, they are termed *syngeneseous*, as in the *sunflower*.

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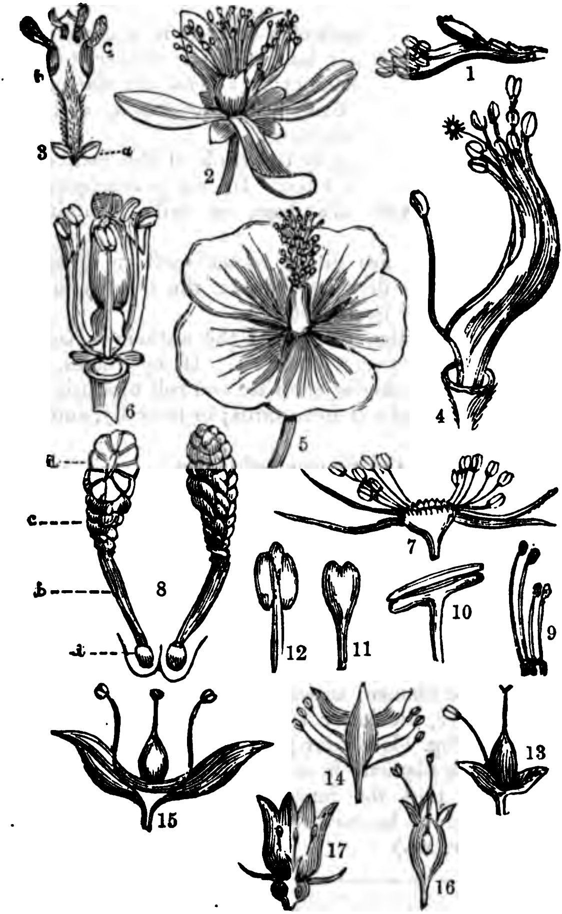
[1] Gr., *hupo*, below; *gune*, the pistil. [2] Gr., *peri*, around. [3] Gr., *epi*, upon. [4] Gr., *gune*, and *andros*. [5] Gr., *monos*, one; *delphos*, a brotherhood. [6] Gr., *dis*, two. [7] Gr., *polys*, many. [8] Gr., *tetra*, four; *dunamis*, superiority.



GROUP XX.

1. Monadelphous.
2. Polyadelphous.
3. Stamen of *faurus*—*a*, glands; *b*, filament; *c*, anther.
4. *Diadelphous.*
5. *Monadelphous.*
6. Tetradynamous.
7. Diadelphous.
8. Pollinia of orchis—*a*, pretinaculum; *b*. caudicle; c. pollen-masses; *d*, section of ditto.
9. Didynamous
10. Versatile.
11. Innate.
12. Adnate.
13. Hypogynous.
14. Ditto.
15. Perigynous.
16. Epigynous.
17. Epipetalous.

The stalk or filament of a stamen is analogous to the petiole of a foliar leaf, and the anther to the blade. When the filament is absent the stamen is sessile. If only a filament is developed, and no anther, the stamen is abortive.

The anther is formed by the blade of the leaf being rolled back into two lobes. In the parenchyma of each lobe are two chambers, or cells, containing *pollen.*

Anther lobes are either *monothecal*[1] or *dithecal*,[2] according as the division between the two chambers remains entire or is absorbed.

When the pollen is mature, the anthers *dehisce* or burst, either by pores or valves. If by valves, the valves rupture either at the base and roll upwards; or at the summit and roll downwards; or laterally, and roll backwards.

That part of the filament which is attached to the anther is termed the *connectivum.*[3] The two lobes of the anther are frequently separated, or caused to diverge from each other by the division of the connectivum.

When the lobes of the anther are united to the filament along their whole length, so that the filament appears to pass through them, as in the *buttercup*, the anther is said to be *adnate.*[4] (Fig. 12, Gr. xx.)

When the filament appears to terminate at the base of the anther, the latter is said to be *innate*, as in the *mallow.* (Fig. 11, Gr. xx.)

When the filament is so attached to the middle of the anther, that the latter appears to be poised on it, it is said to be *versatile*,[5] as in the grass family. (Fig. 10, Gr. xx.)

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[1] Gr., *monos*, one; *theca*, a box. [2] Gr., *dis*, two. [3] L., the connecting part. [4] L., *ad*, to; *natus*, born. [5] L., *versatilis*, easily turned.

Anthers[1] are usually oval in outline, but other forms are frequently met with, such as *reniform*, *spherical*, *linear*, *contorted*, *flexuose*, &c. When anthers discharge themselves on the side directed towards the centre of the flower, they are said to be *introrse*;[2] when on the side turned from the centre and towards the circumference, they are *extrorse*.[3]

Filaments are either coloured and marked in the same manner as the petals, or expanded in a petaloid manner; sometimes they are densely clothed with hairs (*stupose*), as in the *common spiderwort*.

The development of some flowers ceases with the production of stamens. Other flowers have no stamens, but develop a pistil.

When these two forms of flower are borne on the same plant, as in the mulberry or the hazel, the plant is said to be diclinous as to its flowering system. When stameniferous flowers are borne on one plant, and pistiliferous on another, the plant is said to be *diœcious*, as *willows*, *poplars*, *lychins*, &c.

Where both stamens and pistils are present in the same flower, the plant is said to be *hermaphrodite*.

Pollen is the powdery substance found in the anthers, and generally discharged from them when they are matured. It sometimes exists in masses, as in *orchids* and *asclepiads* (Fig. 8, Gr. xx.); at others in bead-like threads (*moniliform*), as in *sea-wrack* (*Zostera marina*).

According to Schleider pollen is developed in the chambers of the anthers in the following manner. A column of large cells, which he calls parent-cells, is developed in each chamber. In each of these cells is a nucleus, which, when the cell is matured, enlarges and sub-divides into four. The divisions eventually acquire a cell membrane, absorbing that of the parent-

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1 Gr., *antheros*, belonging to the flower. 2 L., *introrsum*, inwardly. 3 L., *ex*, out.

cell, and becoming *special parent-cells.* These special parent-cells next develop one, and sometimes two, pollen grains in their interior, the original cell membrane becoming also more or less absorbed. The absorption is sometimes so incomplete that the pollen grains cohere in fours, as may be seen in many *heaths* and *epacrids,* and also in *Epilobium montanum.* Instances may be occasionally found in most pollens where the absorption of the original cell membranes has not been completed. The stringy adhesiveness of the pollen grains in the evening primrose is produced by this cause.

Pollen grains are of various forms, which are always constant to the variety of plant to which they belong. They are frequently covered by thickenings and markings, are sometimes tuberculated or echinate, are variously coloured, and when perfect they contain a fluid termed *fovilla.*

Function.—The function of pollen is to fertilize the ovules. The pollen cell may be considered as the unicellular condition of all phænogamous plants. It is quickened into growth and multiplied by being brought into contact with, and nourished by, the secretions of the stigma. Much imperfect pollen, however, is formed, especially in hybrid plants; the pollen-cells or grains are present, but they are destitute of fluid, and seem like empty bags. When pollen is discharged from the anther, the stamen withers and dies. Pollen is mostly produced greatly in excess of the amount required to fertilize the ovules, much of it being lost during its dispersion.

Discharge of Pollen.—The manner in which pollen is dispersed varies according to the habit of the plant producing it. In some plants, some of the *campanulas* for example, we can scarcely say there is any dispersion, as fertilization takes place immediately before the expansion of the flower.

In the common gorse one-half the anthers discharge their pollen before the expansion of the flower, and the other half after, thus giving the flower a double chance of becoming fertilized, the stigma being not always sufficiently developed to receive the pollen before the expansion of the flower. The structure of flowers in the pea-family seems specially adapted, in most instances, to secure self-fertilization. On the other hand, many flowers are so constructed as to render self-fertilization almost impossible, as pointed out by Mr. Darwin in his work on the "Fertilization of Orchids." In their case bees and other insects are the unconscious agents by which the pollen is conveyed to its proper destination; the wind, too, is an agent, though a more uncertain one, in the same work, in which also gravity occasionally assists.

Dispersion by gravity must prevail in such plants as the *mulberry*, where the stameniferous flowers are small in number, and generally produced at the summit of the tree. And it is only in a still atmosphere that the pollen can by this means reach the pistiliferous flowers. A special mode of dispersion, due to an irritability in the filaments for example, seems to prevail in some plants. In the genus *Berberis*, and probably in the whole order, it prevails in great intensity, as may be seen by touching one of the filaments with a pin or bristle, when it will spring from its place on the face of the petal with great force toward the pistil, and there discharge its pollen, and then gradually fall back and wither. The same result may be obtained from all the stamens in succession, but seldom, if ever, twice from a single stamen.

In other plants the anthers approach the stigma by degrees and in succession to discharge their pollen, and having performed their mission fall back and die away.

Pollen has considerable vitality, and may be kept

for months, and even years, and still retain its fertilizing power. It is occasionally sent from one country to another by horticulturists to fertilize such plants, as produce there female flowers only.

Group XXI.

1. Arum maculatum.
2. Viola arvensis.
3. Prunus insititia.
4. Lamium maculatum.
5. Larix europæus.
6. Narcissus pseudo-narcissus.
7. Ranunculus arvensis.
8. Cardamine pratense.
9. Geranium.

In Group xxi. pollen grains of nine different plants are shown, as the grains appear under a half-inch power of the microscope. In examining these grains it is often impossible to discern the markings, unless *the pollen is* swollen by immersion in some fluid, as

water. If the water is added while the pollen is under examination, the grains are seen to swell with great rapidity, and in some cases to burst and discharge the fovilla.

CHAPTER XIX.

THE FLOWER—(continued)

THE PISTIL.

Description.—The pistil is the centre of a complete flower, and the female organ or system. It may consist of a single metamorphosed leaf, or of several leaves arranged in a verticel, or spiral. These leaves are termed *carpellary* leaves, each one being a *carpel.*[1] They are either free and distinct from each other (*apocarpous*[2]), or more or less united together (*syncarpous*[3]).

A simple pistil consists of one carpellary leaf, folded together by its inner margins; sometimes prolonged at its apex into a column or *style,*[4] at the summit of which is a portion destitute of a cuticle, called the *stigma,*[5] which exudes a viscid secretion.

The Ovary.—That portion of the leaf where the margins are in contact developes an excrescence which is either confined to the wall of the *ovary,*[6] as the lower part of the pistil is termed, or it may be prolonged some distance into the chamber of the ovary. This excrescence is known as the *placenta,*[7] or *spermaphore.*[8] Carpellary leaves, therefore, are analogous to

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[1] Gr., *karpos*, a fruit. [2] Gr., *apo*, separate. [3] Gr., *syn*, together. [4] L., *stylus*, a stake. [5] Gr., *stigma*, a mark. [6] *Ovum*, an egg. [7] L., *placenta*, a flat cake. [8] Gr., *sperma*, a germ ; *phoreo*, to bear.

foliar leaves, since their inner margins are always directed toward the axis.

When two or more carpels are developed in a verticel they are often coherent (*syncarpous*) either partially or along their entire length. The styles may be free and the carpels coherent, as in *Nigella;* or the styles may be coherent and the carpels free, as in some *malvaceæ.*

When in a syncarpous ovary, as in the *poppy* for example, the united margins grow towards the centre, so as to divide the ovary into cells, the partitions are called *septæ,*[1] or *dissepiments.*[2]

An ovary is said to be bilocular, trilocular, or multilocular, according to the number of cells into which it is divided.

When the placenta is only slightly developed, so as not to extend far beyond the wall of the ovary, it is termed *parietal.*[3]

When the dissepiments grow to the centre of the ovary, a central or axile placenta is produced, and the attached ovules are directed outward.

One or more ovules may be developed on each placenta.

The flowering axis itself occasionally bears the ovules, as may be seen in the common *rhubarb,* in which a solitary ovule is developed at the summit of the axis, the three carpellary leaves bearing no placenta or ovules.

In the *pink* family there is prolonged, through the entire length of the ovary, an axial column, on which numerous ovules are borne.

In *geraniums* a few ovules are borne on the axis, each of which is covered by the base of a carpellary leaf. The axis in this case is carried up to the ex-

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[1] L., *septum,* a division. [2] L., *dissepio,* to separate.
[3] L., *paries,* a wall.

tremity of the carpellary leaves, to the summit of which the styles are adherent. This extension of the axis is termed a *carpophore.*[1]

Occasionally an internode is developed between the stamens and the carpels, so that the carpels seem to be borne on a short stalk, which is termed *gynophore.*[2] It is difficult to determine whether this is really an internode of the axis, or caused by the stalks of the carpellary leaves cohering.

In cruciferous plants, a membranous expansion completely separates the two carpellary leaves, forming a bilocular ovary; this is termed a *replum.*[3]

Inferior and Superior Ovaries.—If the calyx of the flower is adherent to the ovary, the ovary is said to be *inferior*, as it is then crowned by the limb of the calyx. If there is no adhesion, the ovary is *superior*, being the last and uppermost portion of the flower.

Style.—The style, when present, is generally developed at the summit of the ovary, and when not diverted from that position is called *apicilar*. But in some instances the expansion of the ovary takes place on one side only; the style then becomes *oblique*, or *lateral*, as in the *buttercup*. Again, in a syncarpous ovary the base of the style may remain stationary, while the carpels continue to inflate and swell up above, so that the style appears to proceed from the base of the ovary, as in the *borage* tribe, it is then termed *basilar*. The style is commonly cylindrical, but is often cleft or bifurcate. It may become expanded and petaloid, as in the *iris*, or be absent altogether, in which case the stigma is sessile.

Stigma.—The term stigma is always limited to that portion of the pistil that exudes the viscid secretion.

In the iris it is only a slit in the petaloid style.

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[1] Gr., *karpos*, and *phoreo*. [2] Gr., *gune* and *phoreo*. [3] L., *replum*, a leaf of a door.

The stigma is often divided into several lobes corresponding to the number of cells or carpels in the ovary.

Stigmas sometimes assume peculiar forms, which have always been subjects of interest to botanists. In *sarracenias*, or *side-saddle flowers*, they are of an umbrella-like form, completely concealing the stamens. In *asclepias* it is difficult to distinguish the stigmatic portion. In the *poppy* the stigmas radiate on a flattened disc. In many orchids the stigma is only distinguished by a slightly viscid depression in the column.

Function.—The function of the stigma is to attach and nourish the pollen grains. This is done by means of the viscid secretion that exudes from its extremities, which consist of a loose cellular tissue leading to the placenta. The pollen grains being retained in their position on the stigma by the adhesive nature of the secretion, develop tubes which penetrate through the tissue of the stigma, and elongate as they pass through the intercellular passages of the connecting tissue, by the secretions of which they are nourished. Eventually they reach the placenta, which is usually so formed as to serve as a guide to the mouth of the ovules.

Before the pollen tube reaches the ovule it is already a multicellular body, having been subdivided by septa while traversing the intercellular channels of the style and the cavity of the ovary. This division goes on more rapidly in the latter part of its course, though it seems still to be a tube when it reaches the ovule. Here cell multiplication takes place in other directions, and the pollen-tube eventually loses its identity, forming with the ovule, and at its expense, a new and independent organism.

After fertilization the style either falls away and is said to be *deciduous*, or it remains and is said to be

persistent, sometimes continuing to grow in a disproportionate manner to the rest of the carpellary leaf, as in the *clematis*.

In some plants the number of cells in the ovary diminishes after fertilization, owing to the imperfect fertilization of the ovules; those that are fertilized growing and obliterating the cells of those that are not. Many examples exist of multilocular ovaries becoming unilocular fruits.

When the carpellary leaves are developed in verticels, the number of leaves in each verticel, compared with the number of parts in the other verticels of the flower, is generally reduced. For instance, where the calycine, corolline, and staminal leaves are in verticels of five, the carpellary leaves may be one, two, or three in number. Aberrations sometimes occur in which the number is increased, as in the *Herb Paris*, where the number of parts in the verticels being four, five carpels are occasionally produced.

In some of the *Iris* tribe four carpels are occasionally developed, while a trimerous arrangement of the parts of the flower is the normal condition.

Occasionally, also, a double verticel of carpellary leaves is developed, as in the *columbine*.

The carpellary leaves also occasionally revert to the foliar condition. In the *double cherry* this is nearly constant, the single carpellary leaf being always foliar, with sometimes the ovule also in a foliar condition.

CHAPTER XX.

THE OVULE, OR SEED-BUD.

Development.—On cutting open an ovary small pearly excrescences are seen, which are the *ovules*[1] or *seed-buds*, that, when mature, form the seeds. If an

[1] L., *ovulum*, a little egg.

ovary be dissected in an early condition of the flower-bud, the immature ovules may be seen upon the placenta as simple sacs.

By examining a number of flower-buds in different stages of growth, which may readily be accomplished, the changes may be observed which take place during the development of the ovule, from its earliest condition up to its maturity, at the time of the expansion of the flower.

In its rudimentary stage the ovule consists merely of a sac, called the *nucleus*.[1] At its base a thickened ring soon appears, which gradually develops into an integument, covering the nucleus almost to its apex. This covering has been termed the *primine*.[2]

In some ovules a second integument is produced in the same manner as the primine, but it appears not to embrace the whole of the ovule until fertilization has taken place. This membrane is called the *secundine*.[3]

These coats envelop the ovule except at its apex. The nucleus, therefore, is left accessible by an aperture called the *foramen*[4] or *micropyle*.[5]

During the formation of the integuments a large cell begins to develop within the nucleus, but is not completed till after the curvature of the ovule (to be presently described) has taken place. This cell is called the *embryo-sac*, and occupies a position near the apex of the nucleus, which has expanded and absorbed some of the surrounding cells. The embryo-sac is, therefore, placed at the bottom of the micropyle.

Certain parts of the ovule receive special names, which must here be described. They are the following:—

Chalaza.[6]—The point of union between the integuments and the nucleus is termed the chalaza.

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[1] L., *nucleus*, a kernel. [2] L., *primus*, first. [3] L., *secundus*, second. [4] L., *foramen*, a hole. [5] Gr., *micros*, small; *pylon*, a gate. [6] Gr., *chalaza*, a spot on the skin.

Funiculus.—When the ovule is stalked, the stalk is called the *funiculus*[1] or *podosperm*;[2] and, when there is no podosperm, but the ovule is attached directly to the trophosperm, it is said to be sessile.

In Gr. xxii., Fig. 9, the micropyle is shown at *m*, and the passage at *p*; in Fig. 2, an ovule possessed of a funiculus; and in Fig. 3, sessile ovules.

Curvature.—During the growth of the ovule it may become more or less curved, and at maturity is often inverted. In an inverted ovule the micropyle occupies the base, and the chalaza the apex; but a connection is maintained between the base of the ovule and the base of the nucleus by a process termed the *raphe*,[3] which is attached to the chalaza, and forms a kind of network. It may be considered as an extension of the podosperm, or an addition to it. The position of the raphe is shown in *r*, Fig. 9, Gr. xxii.; and a fine example of an expanded raphe is seen in the ovule of the *geranium*, represented in Fig. 13 of the same group. This figure also shows the micropyle, the nucleus, and the embryo-sac very distinctly.

The curvature of ovules is an important question, for by its means the distinctions between several groups of plants may be determined. The most important varieties are the following; but it must be distinctly understood that numerous intermediate forms occur.

Orthotropous.[4]—In this form there is no curvature, and the ovule is erect. It is not the commonest condition, but is described first because it represents the early stage of all ovules before curvature has set in. A large orthotropous ovule, which can be examined without the aid of a microscope, is found in the *spiderwort*, and is represented in Fig. 5, Gr. xxii.

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[1] L., *funiculus*, a little cord. [2] Gr., *pous*, a foot; *sperma*, seed. [3] Gr., *raphe*, a seam. [4] Gr., *orthos*, straight; *tropos*, mode or arrangement.

Another example is afforded by the *common rhubarb*, shown in Fig. 4, Gr. xxii.

Anatropous.[1]—The opposite condition to the orthotropous is the anatropous, or reversed ovule, in which the curvature has carried the micropyle to the base of the ovule. This form is very abundant, and examples are shown in Figs. 6, 10, 12, Gr. xxii., which represent the ovules of *acer campestris, caltha palustris*, and the *parsnip*, respectively.

Amphitropous.[2]—A form of ovule, intermediate between the two above described, is found in *veronica*, and some other plants. It is termed amphitropous, and is shown in Fig. 7, Gr. xxii.

Campylotropal.[3]—Another intermediate form, in which the nucleus is parallel to the podosperm, is called campylotropal. It may be observed in *lychnis floscuculi*, shown in Fig. 8, Gr. xxii.

Lycotropal.[4]—In this form the ovule has assumed somewhat the shape of a horse-shoe. It is by no means of frequent occurrence. A lycotropal ovule is shown in Fig. 14, Gr. xxii.

Position of Ovules in the Ovary.—The position of ovules in the ovary is a matter demanding the attention of the student. When they stand up from the base of the ovary, as in the *rhubarb* (Fig. 4, Gr. xxii.), they are said to be *erect*. When they hang from the apex, as in the *umbelliferæ*, they are called *suspended* ovules, of which the *parsnip* (Fig. 12, Gr. xxii.) serves as an example. When attached to the side of the ovary, and growing downwards, as in *acer campestris*, they are named *descending* ovules. On the other hand, when the ovules grow upwards from the side of the ovary, as in *veronica serpyllifolia* (Fig. 7, Gr. xxii.), they are said to be *ascending*.

Naked Ovules.—In certain groups of plants—the

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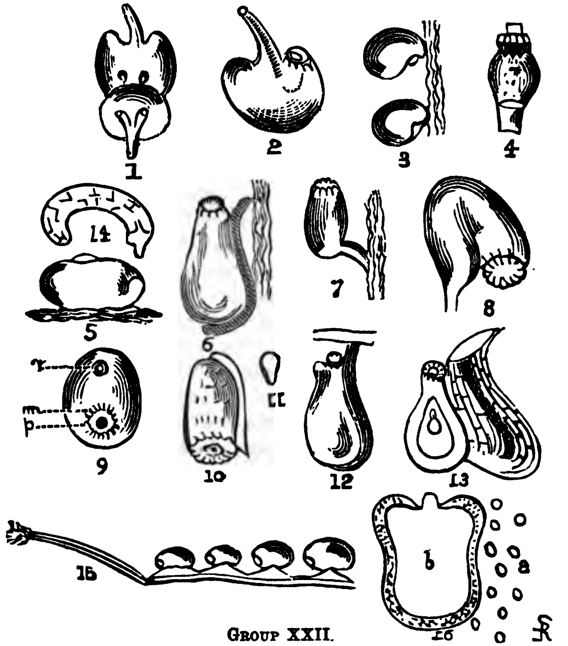
[1] Gr., *ana*, over. [2] Gr., *amphi*, about. [3] Gr., *campylos*, curved. [4] Gr., *lykos*, a hollow disc.

conifers and *cycads*—the ovules are not borne in an ovary, but are developed on a scale-like placenta, and are described as being naked. These plants do not produce perfect flowers.



GROUP XXII.

1. Naked ovule of *larch*.
2. Ovule of *cochlearia anglica*, showing podosperm.
3. Sessile ovules.
4. Orthotropous ovule of *rhubarb*.
5. Ditto of *spiderwort*.
6. Anatropous ovule of *acer campestris*.
7. Amphitropous ovule of *veronica*.
8. Campylotropal ovule of *lychnis flos-cuculi*.
9. Transverse section of anatropous ovule, showing *r*, raphe; *m*, micropyle; *p*, passage.
10. Ovule of *caltha palustris*.
11. Embryo-sac of *garden peony*.
12. Suspended ovule of *parsnip*.
13. Ovule of *geranium*.
14. Lycotropal ovule.
15. Ovule, trophosperm, style and stigma of *viccia sepium*.
16. Microspore a, and macrospore b, of *globularia pilulifera*.

Fertilization of Ovules.—We have before described the manner in which the pollen-grains become attached to the stigma, and develop tubes which pass down the style into the ovary, and finally enter the passage of the micropyle of the ovule. It is necessary in this place, therefore, merely to call attention to the fact that the pollen-tubes are guided into the micropyle by the peculiar formation of the trophosperm, which develops discs beneath the ovule to serve that end. In Fig. 15, Gr. xxii., the ovule, trophosperm, style and stigma of viccia sepium, are represented as showing this adaptation to the purposes of fertilization.

On the pollen-tube reaching the embryo-sac, its extremity undergoes cell-multiplication, the new cells being nourished apparently by the semi-fluid contents of the embryo-sac, which are thereby absorbed, together with part of the sac itself. The fertilized ovule then becomes a seed, and the further changes which it undergoes are described in Chapter XXII.

Analogies.—A typical ovule may be described as consisting of a nucleus covered by one or more integuments. As such, its analogue may be recognised in the growing point and terminal bud of nearly every vegetating axis. The nucleus is represented by the growing point, and the integument by the young leaves, which, in this early condition, seem to differ from the integuments of ovules only by their want of adhesion.

In flowerless plants the ovules are represented by *spores*, shown in Fig. 16, Gr. xxii., and will be fully described in the concluding chapters of this work.

CHAPTER XXI.

THE FRUIT.

Introduction.—After fertilization has taken place, important changes frequently occur in the ovary, and *the parts of the* plant adjacent to it.

The ovary begins to swell, and the carpels of which it is composed sometimes develop in an inordinate degree as compared with the seeds, as may be seen in the *orange*. In other cases the seeds swell to a much greater extent than the carpels, as in the *chesnut*.

When the swelling is complete, the ovary is called the *fruit*, which may therefore be defined to be the *matured ovary*.

In popular language the term fruit is often applied to much more than the matured ovary, the word being used to designate merely an edible product. Thus, the sweet pulpy part of the *strawberry* is not a fruit, botanically speaking, but an enlargement of the calycine interior; the fruits being the little hard bodies commonly called the seeds.

It occasionally happens that the fruit is matured without fertilization having taken place. Instances of this are seen in the *St. Michael's orange*, and the *Corinth grape*, in neither of which are there any seeds.

Modification of Carpellary Leaves.—While the carpellary leaves are being developed into fruit, changes take place in their texture. They may become dry and membranous, as in *campanula;* woody, as in the *nut;* fibrous, as in the *cocoa-nut;* bony, as in *lithospermum;* fleshy or pulpy, as in the *apple* and *peach*.

The carpels may cohere more strongly together after being matured, as in *cohune-nut;* or their cohesion may be destroyed when the seeds are ripened, as in *tropæolum*.

The septa, which divide a syncarpous ovary into chambers, may become obliterated during the ripening of the fruit, and a multilocular ovary is thus developed into a unilocular fruit.

This is owing to the non-fertilization of some of the ovules, and is found constantly to obtain in certain plants. Thus, if an *acorn* be examined late in June, or early in July, it will be found to possess three cells,

each containing two ovules. Only one of these ovules becomes fertilized, and converted into a seed. This single seed forms the fruit, although the ovary appears to have been planned to contain six seeds, two in each of the three original chambers.

On the other hand, a unilocular ovary may apparently become converted into a multilocular fruit in consequence of processes being developed from the lining membrane of the carpellary leaf, which divide the interior of the fruit into chambers. Illustrations of this are seen in *Astragalus* and *Cassia fistula.*

Pericarp.—The envelope formed by the carpellary leaves, constituting the boundary of the chamber or chambers of the fruit, is called the *pericarp.*[1]

The pericarp is usually divided into three layers, analogous to the three layers of the foliar leaf. The outermost of these layers is called the *epicarp,*[2] and is shown at *a*, Fig. 2, Gr. xxv. The middle layer is known as the *mesocarp,*[3] represented at *b*, Fig. 2, Gr. xxv.; and the innermost layer as the *endocarp,*[4] seen at *c*, Fig. 2, Gr. xxv.

The epicarp is analogous to the upper cuticle of a foliar leaf; the mesocarp to the parenchyma; and the endocarp to the under cuticle.

The layers are not always distinguishable, especially in dry pericarps; but in some fruits, as in the *cherry*, they are separable.

The epicarp is observable in the *plum* or *cherry* as a smooth, toughish skin, which can readily be removed.

The mesocarp is the soft, pulpy part of the fruit.

The endocarp is the bony shell which encloses the kernel or seed.

Endocarps are sometimes leathery, or *coriaceous,*[5] and sometimes membranous.

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[1] Gr., *peri*, about; *karpon*, a fruit. [2] Gr., *epi*, upon. [3] Gr., *mesos*, middle. [4] Gr., *endos*, inner. [5] L., *corium*, leather.

Mesocarps are generally fibrous or fleshy.

Dehiscence.—Many fruits when dry open and allow the seeds to fall to the ground, as in the *pea*. Such fruits are said to *dehisce*,[1] and the process is called *dehiscence*.

On the other hand, many fruits do not dehisce, and are hence called *indehiscent*. The *apple* and *cherry* may be cited as examples.

Valves.—When a dehiscent fruit separates regularly round its axis, the pieces into which it splits are called *valves*, and the axis from which the valves separate is known as the *columella*.[2]

The number of valves usually indicates the number of the original carpels, but in some cases this number is doubled, in consequence of dehiscence taking place along the part of the carpellary-leaf analogous to the midrib of the foliar leaf.

Sutures.—The line along which dehiscence takes place is called the *suture*.[3] The suture along which the seeds are borne is called the *ventral*[4] suture. The line which is—in position—analogous to the midrib of a foliar leaf forms the *dorsal*[5] suture, and is never seed-bearing.

The *pea* (Fig. 3, Gr. xxiv.) shows these sutures admirably, the pea-bearing side being the ventral suture, and the opposite side the dorsal.

Dissepiments.—Partitions are frequently found in syncarpous fruits, extending from the ventral suture and dividing the fruit into chambers. These partitions are called *dissepiments*[6] or *septa*,[7] and can be well seen in the *iris* or *lily*.

Mode of dehiscence.—The mode of dehiscence in

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[1] L., *dehisco*, to open. [2] L., *columella*, a little column. [3] L., *sutura*, a seam. [4] L., *venter*, the belly. [5] L., *dorsum*, the back. [6] L., *dissepimentum*, a partition. [7] L., *septum*, a division.

different fruits varies greatly. It may take place by means of sutures, which may split at the base and roll upwards, as in the *wallflower*, or the splitting may commence at the apex and travel downwards, as in *epilobium*.

Dehiscence may also take place by means of holes called pores, and these again may occur either at the apex of the fruit, as in the *poppy*, or at the base, as in *campanula*.

Valvular dehiscence may take place under three conditions. In the first case the splitting occurs along the dissepiments, as represented in section in Fig. 1, Gr. xxiii., and the dehiscence is called *septicidal*.[1] An example is found in *rhododendron*.

1 2 3

GROUP XXIII.
1. Septicidal dehiscence. | 2. Loculicidal dehiscence.
3. Septifragal dehiscence.

In the second case the splitting takes place along the dorsal suture, and the dehiscence is said to be *loculicidal*.[2] This mode of dehiscence is shown in Fig. 2, Gr. xxiii., and an example is found in *lilies*.

In the third case the dehiscence is again through the dorsal suture, but it occurs in such a manner as to cause the dissepiments to separate from the valves. This mode of dehiscence is called *septifragal*,[3] and is shown in Fig. 3, Gr. xxiii. An example is found in *convolvulus*.

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[1] L., *septum*, and *cædo*, to cut. [2] L., *loculus*, a cell.
[3] L., *septum*, and *frango*, to break.

GROUP XXIV.

1. Lomentum.
2. Ditto.
3. Legume, open.
4. *Follicle.*
5. *Ditto, open.*
6. Diclesium.
7. Utriculus, *dehiscing*
8. Utriculus. [lifera.
9. Mericarps of umbel-
10. *Ditto* ditto.
11. Siliqua.
12. Pepo.
13. Capsule.
14. Capsule. [tically.
15. Pomum, cut ver-
16. Pomum, cut trans-
17. Bacca, do. [versely.
18. Bacca.
19. Samara.
20. Etærio.

A kind of false dehiscence takes place in some plants, as in the *bird's-foot trefoil*, by the breaking up of the pericarp. This must not be confounded with true dehiscence, with which, indeed, it has no connection whatever.

Pseudo-fruits.—Some of the bodies commonly called fruits differ widely from the botanical definition of a fruit. Of these, the *fig* and the *strawberry* are the most conspicuous examples.

In the *fig* the flowering axis is transformed into a pseudo-fruit,[1] and forms the juicy portion which is generally considered to be fruit. The fruits are in reality the little hard bodies commonly called seeds.

In the *strawberry* the enlarged calyx lining of the flower develops into the pseudo-fruit; the true fruits being the little hard nuts distributed over the surface.

Cohesion and Adhesion.—Fruits, like ovaries, can be divided into syncarpous and apocarpous, according to whether the carpels cohere or remain separate.

Like ovaries, also, they may be inferior or superior, for it is clear that the ripening of the fruit makes no alteration in its position relative to the floral organs.

In the case of inferior fruits, such as the *apple*, the tube of the calyx becomes incorporated with the epicarp, and is not distinguishable as having a separate existence. The teeth of the calyx also remain on the top of the fruit, and are seen in the *apple* as a little brown coronet.

Aggregated Fruits.—Some plants have their fruits aggregated together. These aggregated fruits may arise from a single flower, as in the *raspberry* and *strawberry;* or they may be the aggregations of an entire inflorescence, as in the *mulberry* and *pine-apple.* In this last-named instance the leaves of the perianth become succulent after flowering, and contribute to

[1] L., *pseudo*, false.

the formation of the fruit. The *pine-apple* is therefore a pseudo-fruit.

Subterranean Fruits.—Some few plants mature their fruits underground. After fertilization the fruits bury themselves in the soil, and if any obstruction prevents their so doing, the peduncle dries up, and the fruit withers away.

Arachis hypogea and *trifolium subterraneum* may be cited as examples.

Classification of Fruits.—The classification of fruits has been a subject of much controversy; for, however readily the different kinds may at first sight appear to fall in with certain modes of classification, difficulties are sure to arise sooner or later.

The principle here adopted is to divide fruits into two sections, simple and aggregated. The simple fruits are again divided into syncarpous and apocarpous. The syncarpous are sub-divided into dehiscent, indehiscent, and schizocarpous; the apocarpous into dehiscent and indehiscent.

The aggregated fruits are divided into those which are the product of a single flower, and those which are produced by an inflorescence.

The classification may be readily understood from the following table:—

1. SIMPLE FRUITS.

A. Syncarpous.	*B. Apocarpous.*
(*a*) **Dehiscent.**	(*a*) **Dehiscent.**
(*b*) **Indehiscent.**	(*b*) **Indehiscent.**
(*c*) **Schizocarpous.**	

2. AGGREGATED FRUITS.

A. Produced by a Flower.
B. Produced by an Inflorescence.

SIMPLE FRUITS. — *A. Syncarpous.* — **Syncarpous fruits are such as have the carpels united.**

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(*a*) **Dehiscent.**—The chief varieties of dehiscent, syncarpous, simple fruits are as follow :—

Pixidium.[1]—A dry, one-celled, many-seeded, superior fruit, dehiscing transversely, so that the seeds appear to be seated in a cup covered with a lid. An example is found in *Anagallis.*

Siliqua.[2]—A one or two-celled, many-seeded, superior fruit, dehiscing by two valves which separate from the replium. The seeds are attached to two trophosperms. An example is found in the *wallflower*, and an illustration is given in Fig. 11, Gr. xxiv.

Silicula.[3]—This form of fruit only differs from the siliqua in being shorter. A fruit is said to be a silicula when its length does not exceed four times its breadth. Examples are found in the *honesty*, *lepidium*, &c., and an illustration is given in Fig. 11, Gr. xxv.

Capsule.[4]—A one or many-celled, many-seeded, dry, superior fruit, dehiscing by valves or pores. Examples are found in the *primrose* and *foxglove*, and illustrations given in Figs. 13, 14, Gr. xxiv.

(*b*) **Indehiscent.**—The principal varieties of indehiscent syncarpous fruits are as follow :—

Caryopsis.[5]—A one-celled, one-seeded, superior fruit, having the integuments of the seed indistinguishable from the endocarp. Examples may be found in *wheat* and *barley.*

Samara.—A two or many-celled, few-seeded, dry, superior fruit, possessing wing-like expansions. Good examples are found in the *ash*, *elm*, and *maple*, and an illustration is given in Fig. 19, Gr. xxiv.

Glans.[6]—A one-celled, one or few-seeded, inferior, hard, dry fruit, seated in a kind of persistent involucre called the *cupule.* Examples are found in the *oak*,

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[1] L., *pixis*, a box. [2] L., *siliqua*, a pod. [3] Diminutive of *siliqua.* [4] L., *capsula*, a little chest. [5] Gr., *karyon*, a nut; *opsis*, an appearance. [6] L., *glans*, an acorn.

GROUP XXV.

1. Sorosis.
2. Drupe, showing *a*, epicarp; *b*, mesocarp; *c*, endocarp; *d*, seed.
3. Sorus of fern.
4. Hesperidium, transverse section.
5. Etærio.
6. Strobilus.
7. Etærio, in section.
8. Glans.
9. Capsule.
10. Syconus.
11. Silicula.

(*acorn*), *hazel*, *hornbean*, and an illustration is given in Fig. 8, Gr. xxv.

Pomum.[1]—A fleshy, two or more celled fruit, having the seeds enclosed in dry cells with a cartilaginous or bony endocarp. Examples are found in the *apple* and *hawthorn*, and illustrations are given in Figs. 15 and 16, Gr. xxiv.

(*c*) **Schizocarpous.**[2]—Schizocarpous fruits are such as separate into their original carpels when mature, but do not dehisce. The separated portions are called *mericarps*. The two chief forms are the following.

Carcerulus.[3]—A many-celled, few-seeded, dry, superior fruit, whose carpels cohere around a common axis, as in *tropœolum* and the *mallow*.

Cremocarpum.[4]—A two to five-celled, one-seeded, inferior, dry fruit, whose carpels separate from the axis when ripe. Examples are found in the *umbelliferæ*, in *galium*, &c., and an illustration is given in Fig 1, Gr. xxiv.

B. Apocarpous.—Apocarpous fruits are those in which the carpels are not united.

(*a*) **Dehiscent.**—The two chief dehiscent forms of apocarpous fruits are as follow :—

Follicle.[5]—A many-seeded, one-valved, superior fruit. An example is seen in the *columbine*, and an illustration is given in Fig. 5, Gr. xxiv.

Legume.[6]—A fruit similar to the above, but having two valves, as in the *pea*, shown in Fig. 3, Gr. xxiv.

(*b*) **Indehiscent.**—The chief varieties of indehiscent syncarpous fruits are as follow :—

Lomentum.[7]—A lomentum only differs from a legume in being indehiscent. An example is found in *bird's-*

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[1] L., *pomum*, an apple. [2] Gr., *schisma*, splitting; *karpon*, fruit. [3] L., *carcer*, a prison. [4] Gr., *kremo*, to hang. [5] L., *folliculus*, a little bag. [6] L., *legumen*, pulse. [7] L., *lomentum*, bean-meal.

foot-trefoil, and an illustration is given in Fig. 1, Gr. xxiv.

Achenium.[1]—A dry, inferior fruit, in which the pericarp is quite distinct from the seed-coat. Examples are found in the *borage*, *myosotis*, &c., and an illustration is given in Fig. 20, Gr. xxiv.

Utriculus.[2]—A dry, one-celled, one or few-seeded, superior fruit, with a somewhat inflated pericarp. Examples are found in the genus *chenopodium.* (Figs. 7, 8, Gr. xxiv.)

Drupe.[3]—A one-celled, one or two-seeded, superior fruit, having a pulpy mesocarp and a bony endocarp. Examples are found in the *peach* and *cherry*, and an illustration is given in Fig. 2, Gr. xxv.

Bacca,[4] or *berry.*—A many-celled, many-seeded, pulpy, inferior fruit, in which the attachment of the seeds is obliterated when the fruit is ripe, and the seeds become scattered in the substance of the pulp. An example is seen in the *gooseberry*, and illustrations are given in Figs. 17 and 18, Gr. xxiv.

2. AGGREGATED FRUITS.—A. **Produced by a Flower.**

Etærio.[5]—The ovaries are apocarpous and indehiscent, and the little fruits are called *drupels* in the case of the bramble, but this term is not applied to other forms of etærio. An etærio may be dry and seated upon a dry receptacle, as in the *buttercup;* dry and seated upon a fleshy receptacle, as in the *strawberry;* or fleshy upon a dry receptacle, as in the *bramble.* Fig. 5, Gr. xxv., illustrates one form of this fruit, the *buttercup;* Fig. 20, Gr. xxiv., shows the *strawberry;* and Fig. 7, Gr. xxv., the *bramble.*

Cynarhodon.[6]—A very distinct member of the aggregated group of fruits, in which the ovaries are

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[1] Gr., *achanio*, not opening. [2] L., *utriculus*, a little bladder. [3] L., *drupa*, an unripe olive. [4] L., *bacca*, a berry. [5] Gr., *etairos*, a companion. [6] Gr., wild-rose fruit.

apocarpous, the carpels hard, indehiscent, and enclosed within the fleshy tube of the calyx. An example is found in the *rose.*

B. Produced by an Inflorescence.—A few only of the most important of these fruits can be noticed. They are as follows:—

Sorosis.[1]—A spike of flowers converted into a fleshy fruit by the cohesion of the carpels and floral envelopes into a single mass. An example is seen in the *mulberry*, represented in Fig. 1, Gr. xxv.

Strobilus.[2]—An amentum, the scales of which are woody, leathery, or membranous, and spread open when ripe, bearing naked seeds at their bases. Examples are found in the *spruce*, *pine*, and *larch*; and an illustration is given in Fig. 6, Gr. xxv.

Syconus.[3]—A fleshy axis of inflorescence, having the form of a flattened disc, or hollow receptacle, with distinct flowers and dry pericarps. Examples are seen in the *fig* and *dorstenia*, and an illustration is given in Fig. 10, Gr. xxv.

CHAPTER XXII.

THE SEED.

Definition and Description.—A fertilized ovule becomes a seed on arriving at maturity. A seed, therefore, bears the same relation to an ovule that a fruit does to an ovary.

During the transition from ovule to seed, changes take place which are generally strongly marked; a great increase in bulk being one of the most frequent of these changes. Sometimes, however, the alteration is so slight as almost to escape notice. The seed

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[1] Gr., *soros*, a cluster. [2] L., *strobilus*, a fir-cone. [3] Gr., *sukon*, a fig.

consists essentially of an external coat called the *spermoderm*, and an internal portion called the *embryo*, which forms the future plant. Between these there is found in some seeds a nitrogenous substance to which the name of albumen is given.

Seeds are generally enclosed in a pericarp, and are then termed *angiospermous*,[1] but when, as in *conifers* and *cycads*, they are naked, the term *gymnospermous*[2] is applied to them.

Spermoderm.—The covering of a seed is called the *integument*[3] or *spermoderm*.[4] It consists of two membranes—the inner, called the *endosperm*[5] or *endopleura*;[6] the outer called the *episperm*[7] or *testa*.[8] These membranes are entirely cellular, and can rarely be separated.

There is great variation in the texture of the testa. It is a loose, membranous sac in the seeds of *orchids*, a hard bony shell in the *brazil-nut*, and numerous intermediate forms exist. It is beautifully sculptured in *euphorbia* and *scrophularia*, smooth and polished in *aquilegia*, brilliantly coloured in *abrus*, delicately mottled in the *castor-oil* plant, covered with long hairs, as in the *cotton* and *bombax*, and so on.

Some seeds seem to throw off the membranes separately during germination. We have frequently noticed this in *convolvulus*.

The seeds of cruciferous plants appear during germination to possess a mucilaginous layer between the spermoderm and the cotyledons, which is probably a deliquescent condition of the endosperm.

The point of attachment of the seed is called the *hilum*, and is frequently marked distinctly on the seed-coat, as in the *bean*, where it appears as a black scar.

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[1] Gr., *aggeion*, a vessel. [2] Gr., *gymnos*, naked; *sperma*, a seed. [3] L., *integumentum*, a covering. [4] Gr., *sperma*, and *derma*, skin. [5] Gr., *endon*, within. [6] Gr., *pleura*, a membrane. [7] Gr., *epi*, upon. [8] L., *testa*, a shell.

Arillus.—Another envelope entirely or partially covering the episperm is occasionally developed, and is called the *arillus.*[1] Fine examples of this are found in the *mace* that covers the *nutmeg*, and the bright scarlet coating of *euonymus.* It is considered to be merely an expansion of the seed-stalk.

Albumen.—Beneath the spermoderm we find the embryo, but this is occasionally enclosed in a substance known as *albumen.* This substance is not albumen in the chemical sense in which we have used the word in Chapter I., but is so named from its occupying a similar position with respect to the embryo that the albumen, or white, of the egg does to the yolk. The albumen is considered to be the part of the nucleus of the ovule which is not absorbed by the growth of the embryo. When the albumen is absent the embryo is supposed to have absorbed the whole of the nucleus.

Seeds which contain albumen are called *albuminous,* those without it *ex-albuminous.*

Embryo.[2]—The embryo is the portion of the seed destined to form the young plant. It is found immediately beneath the spermoderm, or beneath the albumen where that substance exists.

The embryo consists of—1, the *cotyledons,*[3] or seed-leaves; 2, the *plumule,*[4] or incipient stem; 3, the *radicle,*[5] or incipient root.

Cotyledon.—The cotyledons form the first leaves of the plant, but in some cases they never rise above the ground. They vary in number from one to three or more. In a large class of plants there is only one cotyledon. Such are called *monocotyledons,*[6] and this character is found to accompany the class *endogens.* Another large section of the vegetable kingdom

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[1] L., *arillus.* [2] Gr. *embryon,* a fœtus. [3] Gr. *cotyledon,* a hollow vessel. [4] L., *plumula,* a little feather. [5] L., *radex,* a root. [6] Gr., *monos,* one.

possess two cotyledons, and the plants are hence called *dicotyledons.*[1] This character accompanies the class *exogens.*

A small number of plants, as the *pine tribe*, or *conifers*, have several cotyledons, and are hence called *polycotyledonous.*[2]

Exceptional cases occur among exogens in which only one cotyledon is present, as in the *cyclamen.* More rarely the cotyledons are entirely absent, as in *cuscuta.* In this case the plant is destitute of foliar leaves.

Cotyledons are either thick and fleshy, or thin and leafy. The fleshy condition is usually found in ex-albuminous seeds, and provides a store of nutriment to assist in the growth of the young plant until the radicle has acquired sufficient development to supply that nutriment direct from the ground.

Albuminous seeds have generally thin, green, leafy cotyledons, the albumen performing the same office to the young plant that the fleshy cotyledons do in ex-albuminous seeds.

In some cases the embryo forms but a small portion of the seed, as may be seen in the *vegetable ivory nut*, where it occupies only a minute cavity in a hard bony mass of albumen. In the *grass* family also, a large mass of farinaceous albumen envelopes a small embryo.

The seeds of some plants contain more than one embryo. Occasionally two are developed in seeds which generally possess but one, for it is not unusual to observe seedling plants with double the normal number of seed-leaves.

Cotyledons are generally entire, sometimes lobed, but never compound.

In dicotyledonous seeds the cotyledons are always opposite; in those that are polycotyledonous they are

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[1] Gr. *di*, two. [2] Gr., polys, many.

verticellate; and in monocotyledonous seeds there is occasionally found a second, smaller cotyledon, which is always alternate with, and never opposite to, the larger one.

Folding of Cotyledon and Embryo.—Cotyledons are either spread out flat or folded in a manner similar to the vernation of leaves in the bud. Dicotyledons present two marked varieties of folded embryos. In the one case the radicle[1] is folded back upon the cotyledons so as to lie in the fissure between them, as in the *pea* and *bean.* The radicle is, in such cases, said to be *lateral*, and is represented in *cress.* (Fig. 4, Gr. xxvi.) In other instances the radicle is folded upon the back of one of the colyledons, as may be seen in some of the *cruciferæ.* In this case it is said to be *dorsal.* (Fig. 3, Gr. xxvi.)

The cotyledons of a great number of plants lie flat, without curving or folding. The radicle in such embryos may occupy any position. It is sometimes folded longitudinally along the middle nerve, and is then dorsal; such cotyledons are said to be *conduplicate.*[2] An example is found in the *cabbage*, and an illustration is given in Fig. 1, Gr. xxvi.

Among folded cotyledons some are bent double, from apex to base, as in *heliophila*, when they are said to be *reclinate.* (Fig. 9, Gr. xxvi.)

When the cotyledons cross each other and are rolled up, as in the *beech*, they are called *convolute.*[3] (Fig. 6, Gr. xxvi.)

When the cotyledons are rolled up from the apex downwards, as in the *sycamore*, they are called *circinate.*[4] (Fig. 8, Gr. xxvi.)

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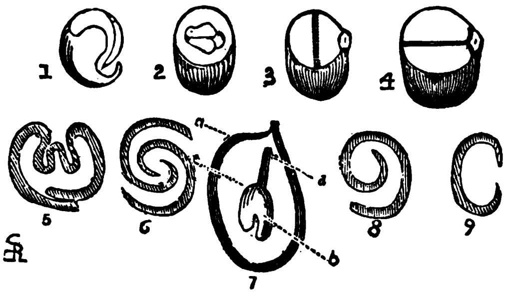
[1] The radicle is the portion of the embryo which develops the root of the young plant. [2] L., *conduplico*, to fold together. [3] L., *convolutus*, rolled together. [4] Gr., *kirkos*, *a circle.*

When the cotyledons are folded into plaits, as in the *beech*, they are *contortuplicate.*[1] (Fig. 5, Gr. xxvi.)

Plumule.—The plumule is the ascending axis of the future plant. In dicotyledonous seeds it is enclosed between the cotyledons, or lies upon them. In monocotyledons it is rolled up in the cotyledon.

It can, in most instances, be easily distinguished, even when the cotyledons are in contact.

It is directed in a direction opposite to that of the radicle, and in some cases already possesses the rudiments of leaves.



GROUP XXVI.

1. Conduplicate cotyledons.
2. Ditto in section.
3. Dorsal radicle.
4. Lateral ditto.
5. Contortuplicate cotyledon.
6. Convolute cotyledon.
7. Seed; *a*, spermoderm; *b*, *d*, embryo; *c*, albumen; *b*, plumule; *d*, radicle.
8. Circinate cotyledon.
9. Reclinate ditto.

The plumule is represented at *b*, Fig. 7, Gr. xxv.

Radicle.—The radicle is the root of the future plant.

The mode in which it is folded has already been described.

It is sometimes directed towards the *hilum*, and at others turned from it.

In some cases the radicle forms the largest portion

[1] L., *contortuplicatus*, twisted together.

of the seed, as in the *cyclamen*. In others it is very minute, as in the *calceolaria*.

Dispersion.—Seeds being destined to reproduce or perpetuate the species, are dispersed in various ways, according to the habit of the plant.

In plants that inhabit sheltered places, such as *violets*, *primroses*, and *balsams*, the seeds are dispersed by the sudden rupturing of the capsule, and are in certain cases, as in *balsams*, projected some distance by the elastic force of the rupturing tissue.

Many of the plants which live in the open country have their seeds provided with a feathery pappus (Fig. 7, Gr. xvii.), as in the *compositæ*. This serves as a parachute, and the seed is borne along by the breeze until some obstacle checks its progress, or the wind drops, or rain destroys the feather.

Other plants, such as the *ash*, have winged processes, and the seeds are carried by the force of the wind to a distance from the parent plant.

Others, again, such as the common *burr* and *teasle*, are provided with hooks and grapples, which, becoming attached to the skins of animals, are thus dispersed.

Some seeds are actually planted by animals, as *acorns* by the squirrel.

Numerous other modes of dispersion occur, the observation of which will afford great pleasure to the student.

CHAPTER XXIII.

GERMINATION.

Having traced the history of a flowering plant from its earliest state to the production of seeds to perpetuate its species, we must now describe the changes which take place in the seed during germination.

The seed, when ripe and ready for germination, is usually hardened and contracted into a less bulk than it occupied previously to its ripening. This arises from its having parted with the water that held the various cell-contents in solution, and hence in consequence having become more carbonized.

Vitality.—This hardening enables the seed to preserve its vitality for a length of time. Many seeds retain their vitality for a number of years if removed from the influence of the atmosphere. The seeds of *docks, black nightshade,* and many other of our common weeds, may remain in the ground under the accumulated rubbish of years, and yet when the ground is cleared and tilled they will germinate, and though carefully destroyed, new crops come up every year as fresh soil is brought to the surface.

The length of time during which seeds will retain their vitality depends upon the nature of the compounds of which the seed is composed, and upon the conditions in which it is placed.

Thus it is found that when the chemical elements are combined in a stable form, as in starch, the vitality is preserved for a much longer period than when they are unstably combined, as in oily seeds.

To preserve them from germination or decay it is also necessary that seeds be kept perfectly dry and not too warm.

Seeds are said to have germinated after lying for centuries in tombs.

Barley, oats, and other grain have been exposed to a temperature below freezing-point for a lengthened period without destruction, and the seeds of the *medicago,* of which the South African wool is often full, will germinate after being boiled.

Conditions favourable to Germination.—Certain conditions are necessary to insure germination, and these are the opposite of those required to arrest that

process. They are (1) *moisture,* (2) *temperature,* (3) *air,* (4) *chemical rays of light.*

1. *Moisture.*—We have seen that, to arrest germination, dryness is essential. So, on the other hand, a certain degree of moisture is requisite to insure it, water being absorbed by the seed as the first step towards germination.

2. *Temperature.*—A certain temperature is necessary to enable a seed to germinate, and the degree of heat varies according to the nature of the plant, tropical plants requiring a higher temperature than natives of cooler regions. Our common grain crops could not grow in the tropics in the dry season, because the heat is greater than they require for germination, and seeds from tropical countries will not germinate in the open air in England, because the temperature falls short of their requirements.

3. *Air.*—The access of air is necessary, for we find that seeds buried deep in the soil, where air can scarcely penetrate, do not germinate, though the temperature and moisture may attain the required amount. The plant is partially supplied with oxygen and nitrogen from the air.

4. *Chemical Rays of Light.*—These are the invisible rays which lie beyond the extreme purple of the spectrum,[1] and exercise a considerable influence in inducing certain chemical changes. They penetrate to a much greater distance than the ordinary heat and light-giving rays, and seem to be necessary to the performance of the changes which take place during germination.

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[1] The spectrum is the seven-hued band of light formed by decomposing a ray of white light. Certain dark rays, lying beyond the light-giving rays, exercise peculiar chemical properties, and are hence called *chemical rays.* See volume on "Light" in this series.

Process of Germination.—The first stage in the process of germination appears to be somewhat retrogressive.

The seed absorbs moisture, which softens and swells the parts, restoring the seed to much the same state as it possessed before ripening. Chemical action then sets in under the influence of the chemical rays; the insoluble starch is converted into soluble sugar or dextrine, and the cell-contents for the most part become soluble. During this change heat is developed.

Cell formation now commences, and the radicle is protruded through the spermoderm, and seeks a position remote from the light, usually descending perpendicularly into the soil. The cotyledons expand, and the plumule begins to develop, and grows in a direction opposite to that of the radicle, ascending towards the light.

By the time the plumule reaches the surface of the ground, the radicle has become sufficiently developed to seek for and supply nutriment to the young plant, which has hitherto derived support from the stores belonging to the seed.

Leaves are now developed, and the plant enters upon its ordinary course of existence.

Time of Germination.—The length of time which elapses between the sowing of the seed and its germination varies in different plants.

The seeds of annuals[1] germinate rapidly, sometimes in a few days.

The seeds of perennials germinate more slowly, and some palm-seeds remain several years in the soil before the young plant appears.

In a few plants the seeds germinate in the pericarp.

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[1] Plants that die at the end of the season are called annuals; those which live for years, perennials.

Persistence of Cotyledons.—Some fleshy cotyledons remain in the soil altogether. These never possess a green colour.

All cotyledons that are green, or acquire a green colour, rise above the ground, some to fall quickly away, others to remain a considerable time, and in one case to persist during the whole life of the individual. This remarkable plant is the *welwitschia mirabilis*, a tree attaining considerable dimensions, and living probably for centuries. The only foliar organs it possesses are the cotyledons, which, though themselves supplying nutriment to the radicle in the early part of its existence, must be nourished by the root in their later stages.

This latter fact has long been familiar to horticulturists, for they require a good *balsam* to have its cotyledons perfect when the plant is shown in bloom. In this case the cotyledons are necessarily nourished by the root.

Modes of Germination.—Germination of seeds having cotyledons takes place in two ways, which are termed *exorhizal*[1] and *endorhizal*.[2]

Exorhizal.—The germination is said to be exorhizal when the radicle is developed directly from the base of the embryo, as in the *maple.*

Endorhizal.—But when the base of the embryo produces a tubercle internally, which pushes through the apex of the radicle during germination and becomes the root, the germination is said to be endorhizal. An example is seen in *wheat.* The ruptured integument sheathing the base of the young root is called the *colecorhiza.*[3]

Heterorhizal.[4]—The spores which serve the purpose of seeds in acotyledons have no embryo, and germina-

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[1] Gr., *exo*, outwards; *rhiza*, a root. [2] Gr., *endon*, within.
[3] *Gr., coleos.* [4] Gr., *heteros*, various.

tion takes place from any part of the surface, and is called *heterorhizal*. *Ferns* belong to this group.

Germination of Parasites.—The seeds of parasitic plants[1] will not germinate in the earth, but only on the plant from which they derive their nutriment. The radicle in this case takes a direction towards the body to which the seed is attached.

Some *orchids* are said only to be parasitic during germination. Their seeds germinate on grass, and the roots eventually make their way into the soil.

Secondary Modes of Reproduction.—Some plants have a secondary mode of reproduction. Buds are formed in the axils of the leaves, which become detached and fall to the earth, and germinate as ordinary seeds. Not being produced by fecundation, they have no title to be considered seeds, though ignorant gardeners persist in so calling them.

CHAPTER XXIV.

CIRCULATION OF FLUIDS IN PLANTS.

Circulation of the Latex, or Cyclosis.—In the early pages of this work a peculiar kind of tissue is described, called laticiferous tissue, as containing a fluid known as latex. The motion or circulation of this fluid is termed *cyclosis*.[2]

The tissue consists of a network of vessels, which are contiguous and communicate with each other, either by approximation or by transverse channels. The vessels are flexible, and expand or contract, so as to appear threadlike, or even to disappear altogether in various portions of their length, and to

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[1] Parasites are plants that grow upon others, and derive their nutriment from them. [2] Gr., cyklos, a circle.

distend or widen out in an irregular manner in other portions, especially in the neighbourhood of the transverse channels.

The tissue occurs in many parts of flowering plants, being found in the root, stem, leaves, corolla, &c. In endogens it traverses the woody bundles of the stem; but in the stems of exogens it traverses the parenchyma of the bark in single tubes, or as a fine network; and in the form of capillary vessels it is present in the hairs of many plants.

The latex is a highly elaborated juice, more or less dense, either transparent or opaque, and yellow, red, brown, or milky in colour. It is mostly viscid, and partially insoluble in water. Upon exposure it separates into a clot, or *coagulum*,[1] and a thin fluid, or *serum*.[2] When observed under the microscope, before this separation takes place, it has a turbid appearance, with *grumous*[3] masses floating about in a fluid, accompanied in some instances, as in certain *euphorbias*, by numerous prismatic bars of very uniform dimensions. In other species of the same genus, masses in the shape of dumb-bells have been observed.

The natural flow of the latex is difficult to observe in consequence of the rapidity with which the vessels empty themselves as soon as they are ruptured. Nevertheless, if certain plants are at hand, such as *ficus elastica* (which can be obtained as a pot-plant at any nursery), or *calystegia sepium* (which grows in most hedgerows, and is a weed in many gardens), excellent opportunities are afforded of seeing that which can only be imperfectly described. Both plants yield the opaque, milky kind of latex.

In *calystegia* the inner sepals of the flower are

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[1] L., *coagulum*, a clot. [2] L., *serum*, a liquid. [3] L., *grumus*, a heap of earth.

extremely thin, sufficiently so to show the motion of the latex through the vessels, by means of transmitted light under the microscope.

By removing the stipule from a plant of *ficus elastica*, separating the upper from the under surface, and examining the latter, the same result may be obtained.

The motion is seen to be both in an upward and downward direction in contiguous channels; now rapid, now slow, or stopping entirely in places, either from an accumulation of the grumous particles, or in consequence of some invisible obstruction, perhaps a lowering of the temperature. Temperature has a great influence on the motion, and on the secretion and elaboration of the latex, as is shown by the fact that plants of warm latitudes yield this juice much more abundantly than those of temperate or colder climes.

In most instances the young parts of plants have the juice less elaborated than the more matured parts; the fluid being colourless and transparent in half-formed leaves, and coloured and opaque in those that are fully developed. Nevertheless, there are some plants in which the latex is only to be observed in young, growing extremities of the shoots, it being apparently absorbed by the expansion of adjoining tissues, as may be seen, for example, in the *hedge maple* (*acer campestris*).

The function of the latex is doubtless to nourish the tissues. Constant tapping, by depriving plants of the latex, retards their growth, and prevents the development of flowers and fruit.

Rotation.—If some of the unicellular algæ,[1] or even higher plants in their unicellular condition be examined by transmitted light, under a tolerably good microscope, a distinct motion or current of the fluid contents of each individual cell will be observed.

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[1] Seaweeds.

It is most readily perceived when chlorophyll, starch granules, or other solid bodies are present. These particles, when borne along with the current, are clearly perceptible, and indicate the direction and speed of the movement. This phenomenon is termed *rotation*.

The region traversed by this stream of life is that next to the circumference of the cell. The speed is irregular; being sometimes rapid, at others slow, or stopping entirely, and then commencing again. Temperature has a perceptible influence on the rapidity of the motion, as in cyclosis, for it is observed to be more active at a high temperature than a low one, and can be controlled while under observation by causing cold or warm currents of air to play upon the object.

Although this phenomenon was first noticed among the lower algæ, it can also be readily observed in many plants of a higher organization, such as some of the thin-leaved species of *potamogeton*, *elodea canadensis*, and most specially in *valisneria spiralis*, where the large, bright-green globules of chlorophyll form interesting objects as we watch them travelling along their unchanging course.

It has been observed in these higher forms that the current is uniformly in the direction of the circumference of the leaves, or, that it has what may perhaps be termed a centrifugal motion.

Some observers believe they have seen three distinct motions in connection with the inner life of the cells. Thus, in addition to the one already described, they distinguish another, and slower, motion at or towards the centre of the cell. We think, however, that this is readily explained, for, taking into consideration the direction of the current, and the course in which it is compelled to move, it follows that the point most remote from the region of activity must be a point of rest, and all intermediate portions must of *necessity* move slower as they approach that point.

The third motion that has been mentioned is the supposed circulation of a fluid between the cell-wall and the primordial utricle. In delicate investigations of this kind it is so easy to believe that we see what really does not exist, that we can never take the unconfirmed statement of a single individual as a fact. The gelatinous and hyaline nature of the primordial utricle would be very conducive to a deception, and, so far as our observations go, we cannot but think that this is the most probable explanation of the phenomenon.

Although only a few plants are enumerated here as showing the phenomenon of rotation, it is to be assumed as existing in each living cell in every plant.

Circulation of the Sap.—The circulation of the sap is another and distinct phenomenon which is met with in plants of a higher organization than algæ. In fact, it is not till we arrive at plants with roots that we can safely say there is a sap circulation.

The sap is absorbed into the plant by the soft, loose cellular tissue at the extremity of the fibrils of the root; it then ascends through the woody tissue and the bothrenchyma of the stem, till it reaches the leaves (in trees it rises through the whole of the woody tissue and most of the vessels of the alburnum). After passing through the leaves, it descends, in an altered state, through the tissues of the bark, parenchyma, cinenchyma, and liber. It also permeates laterally in its descent through the cellular tissue of the stem.

In exogenous trees this permeation takes place through the medullary rays, secreting part of its substance in the vessels of the wood, and so gradually filling them up and converting the alburnum into heart-wood; thus causing that deepening of colour perceptible in the heart-wood of most exogenous trees. This deposit is most conspicuous in thin, vertical sec-

tions of *mahogany*, or *black walnut*, when examined microscopically. The secreted colouring matter can be readily dissolved out by a solution of potash or carbonate of soda, leaving the vessels in the same condition as they appear in the alburnum. The secretions sometimes, though rarely, have the power of destroying or dissolving tissues in certain localities, as may be observed in *pine* boards, where large cavities occasionally occur filled with turpentine. In the woody portions of *welwitschia mirabilis*, Professor Oliver and Dr. Hooker have described and figured cavities caused in a similar manner, which are filled up principally with silica.

In the descent and lateral dispersion of the sap some of it very probably unites with the ascending sap, causing the stream to reach the leaves in a more refined condition than when in its early crude state. Being further elaborated by subjection to the influence of light and heat as it passes through the leaves, it becomes at length highly carbonized, and forms, in some plants, reservoirs or centres of nutrition, that materially assist the further development of the plant. This is peculiarly the case with fleshy-rooted plants, such as the *bryony*, the *turnip*, and many others. It is also probable that the accumulation of this highly carbonized sap in the dormant, or resting buds, forming the spurs on fruit trees, causes them to develop into flowers and fruit.

Fœcus.—In addition to the secretions contained in the descending sap, which are essential to the health and vigour of the plant, there is a kind of fœcus, or refuse, that is discharged from the roots, and is highly injurious, if not poisonous, to young plants of the same species that may be planted in soil impregnated with it. This fact has long been observed, perhaps before a knowledge of the cause was arrived at; and no person knowing anything about fruit culture would

plant an orchard in ground that had previously been in use for the same purpose. On the contrary, it is a common thing, in fruit-growing districts, to see woods and coppices cleared to make new orchards, and the old orchards planted with forest-trees or converted into arable land.

Another fact seems also to have some connection with the fœcus or refuse of plants. There are certain plants that are partially parasitic, such as the *broom-rapes*, the *bastard toad-flax*, and others, that fasten on to the roots of plants, and derive their sustenance (though to all appearance an unhealthy one) from the excrement that they absorb. This may also account for certain weeds always accompanying particular crops. It is also worthy of remark that these pseudo-parasites cannot be made to grow in any other medium, the habit and taste is inherited, as earth-eating is by certain aboriginal tribes in some parts of the world, but the effete matter does not seem to be transmuted into serviceable tissue.

CHAPTER XXV.

FERNS.

Description.—The reproduction of flowerless plants presents very distinctive characters when compared with that of flowering plants. The representatives of the various organs are found in unexpected regions, and under such strange forms, that one conversant only with flowering plants is at a loss to recognize them. These plants do not produce seeds containing embryos, but are developed from minute cellular bodies resembling pollen-grains, which are called *spores*.[1]

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[1] Gr., *spora*, a seed.

Characters of Ferns.—In ferns we have a class of plants distinct from all others in habit, venation, and mode of reproduction. The circinate vernation of their leaves, ordinarily called *fronds*, is one of their most striking external peculiarities. Their furcate venation is another characteristic belonging almost exclusively to them, and the distribution of their reproductive organs on the leaves forms a third distinctive feature, separating this class from every other in the vegetable kingdom.

The leaves of ferns are produced either from a creeping rhizome, at a greater or less distance from each other, or they are arranged in a whorl or tuft, their bases cohering and forming a conical or trunk-like pseudo-stem. The leaves are either simple (entire or lobed) or compound and variously pinnate. They are mostly stalked, the stalk being termed the *stipe*,[1] the upper portion bearing the lamina being termed the *rachis*.[2] The stipe is frequently clothed with brown membranous scales, or hairs termed *ramenta*.[3] The under surface of the lamina is also occasionally covered with hairs, scales, and mealy appendages of various colours.

Reproductive Organs.—On the lower surface, on the margins, and occasionally on the upper surface of the leaves, are produced the analogues of the fruit, called *sporangia*,[4] which are collected together in linear, curved, or circular masses of a brown colour. They contain the spores, are either naked or covered with a membrane called the *indusium*,[5] and are borne either at the extremity of the veins, at the points or angles of bifurcation, or in the intervenal spaces. The collections of sporangia are termed *sori*,[6] a single

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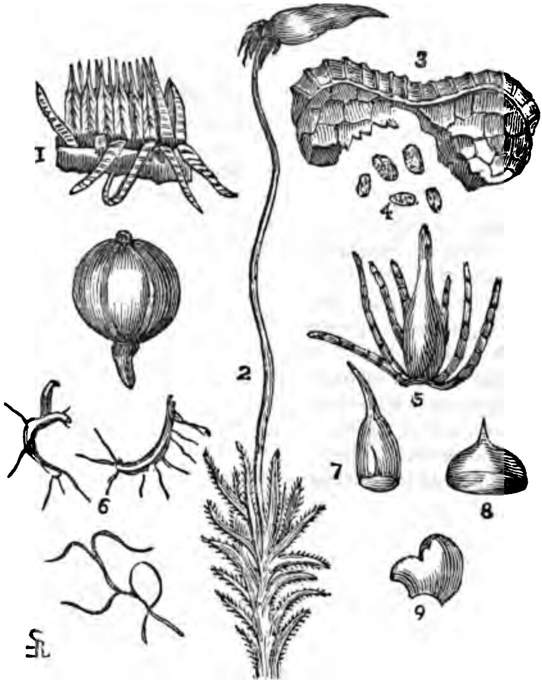
[1] L., *stipes*, a trunk. [2] Gr., *rachis*, the backbone. [3] L., *ramentum*, a shaving. [4] Gr., *spora*, and *aggios*, a vessel. [5] L., *indusium*, a covering. [6] Gr., *sorus*, a heap.

cluster being a *sorus*. Each sporangium is entirely or partially surrounded by an elastic ring, which causes the case to rupture with considerable force when



GROUP XXVII.

1. Peristome.
2. Moss, showing seta and sporangium.
3. Sporangium of *Lastrea*.
4. Spores of ditto.
5. Paraphyses surrounding antheridia.
6. Spermatozoids.
7. Calyptre.
8. Operculum.
9. Prothallus.

mature, scattering the spores in profusion. (Fig. 3, Gr. xxvii.)

When this ring is present the sporangia are said to be *stalked;* when absent, *sessile.* In some ferns only a few of the leaves are fertile or spore-bearing, the others being barren. The barren leaves are usually produced earliest, and the fertile ones later in the season. In other species the majority of the leaves are fertile.

In some ferns the sori are sparsely scattered over the frond; in others they are crowded together, sometimes converting the whole frond, except the stipe, into a spore-bearing surface, in which case it has much the appearance of an inflorescence that has perfected its fruits. They have, from this circumstance, been miscalled flowering ferns.

Indusium.—The indusium is commonly a membranous or cuticular covering of the form of the sori, which becomes ruptured and thrust back by the growth and expansion of the sporangia, either round its entire margin or on one side only. In some species the indusium is cup-shaped, enclosing the sporangia.

Spores.—The *spores* are minute, round sacs, having a double wall. They may be easily obtained by taking a mature fertile frond, and shaking it over paper, when the spores will fall, and be seen as a fine brown powder. Spores are represented in Fig. 4, Gr. xxvi.

Development.—When the sporangia burst, the spores fall to the earth, and sooner or later, according to the nature of the plant and the conditions under which it is placed, they swell and burst their outer sac. The inner coat begins to protrude from the rupture in the form of a scale, of a bright green colour, termed the *prothallus,*[1] represented in Fig. 9, Gr. xxvii. This enlarges, till it appears much like a *liverwort,* and is attached to the ground by filamentous processes. In

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[1] Gr., *protos,* first; *thallos,* a frond.

the under surface of this body are developed organs of two kinds, termed *antheridia*[1] and *archægonia*.[2]

The *antheridia* are unicellular structures in which a second cell is formed, which again becomes multiplied into a number of cells called *sperm-cells*, each containing a *spermatozoid*, which is a little filamentous body, such as is represented in Fig. 6, Gr. xxvii.

The *archægonia* are composed of four tiers of cells, with a central channel leading to a cell analogous to an embryo-sac. This sac ultimately becomes fertilized by the entrance of the liberated spermatozoids.

These latter bodies can only perform their functions in a fluid medium; consequently, a moist atmosphere must prevail, that water may condense upon the prothallus. In the fluid so accumulated the spermatozoids swim about with a vibratile motion, and, entering the channel of the archægonia, complete the act of fertilization.

The embryo-sac then develops a bud, which produces leaves and matures into a plant, which, in its turn, bears sporangia and spores year after year till its death. The remarkable feature is that this one act of fecundation on the prothallus is all that is essential for the whole life of the plant—a life so long that, in many species, it is scarcely possible to estimate its duration.

CHAPTER XXVI.

MOSSES.

Description of Moss.—Mosses are recognized as being cushion-like tufts, or creeping plants, having feather-like expansions for their stems and branches. The

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[1] Gr., *antheros*, flower; *eidos*, like. [2] Gr., *archos*, chief; *gune*, a female.

leaves are densely crowded and always sessile, and are arranged in verticels, spirals, or in two ranks pressed close to the stem, in which case they are scale-like, radiating, and leaf-like, or reduced to mere hairs.

The colours of mosses are brilliant green, golden yellow, brown, white, and sometimes almost black. Winter is the period of their greatest vigour, and they affect sheltered situations on the ground, the bark of trees, the surface of rocks, the margins of pools and bogs.

Reproductive Organs.—The reproductive organs of mosses are analogous to those of ferns. They consist of *antheridia* and *archægonia*, which are developed among the leaves. The former are often accompanied by jointed, thread-like bodies, called *paraphyses*.[1] (See Fig. 5, Gr. xxvii.) The antheridia discharge spermatozoids which fertilize the archægonia, and a *sporangium* is developed upon a stalk or *seta*.[2] Fig. 2, Gr. xxvii., represents the sporangium of a moss capping the seta which rises from the leaves.

Antheridia.—These organs are found in the axils of the leaves, and, as we have seen, are generally surrounded by paraphyses. They are little membranous sacs, containing a turbid fluid, in which spermatozoids are found. This fluid is discharged when the antheridia are ripe.

Archægonia.—The archægonia are found in similar positions to the antheridia, sometimes on the same plant, sometimes on another. They contain a little sac analogous to the embryo-sac of flowering plants.

Sporangia.—The sporangia are seated upon a stalk or seta, and contain the spores. They are surmounted by a veil or hood, called the *calyptra*,[3] which, as we shall presently see, is the remains of the archægonia.

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[1] Gr., *paraphysis*, an offset. [2] L., *seta*, a bristle. [3] Gr., *calyptra*, a hood.

The sporangium itself is usually elliptical in shape, with the sides occasionally grooved or depressed, as in the figure on Gr. xxvii. to which no number is attached, which represents the sporangium of a *split-moss.* It contains the spores, and sometimes possesses a central column, called the *columella.*[1] At the base of the sporangium there is often a swelling known as the *apophysis.*[2]

The calyptra splits in various ways. When the fissure is upon one side it is said to be *dimidiate;*[3] when there are several fissures it is *mitriform;*[4] and other terms are employed to represent other varieties. A calyptra is shown in Fig. 7, Gr. xxvii.

When the calyptra falls away there is generally seen covering the spores a small lid called the *operculum,*[5] represented in Fig. 8, Gr. xxvii. Sometimes the operculum is attached to the inside of the calyptra and comes off with it. Sometimes also there is a deciduous ring around the line of fissure where the calyptra breaks away.

When the operculum falls off the spores are exposed, but there is occasionally a membrane still covering them, called the *peristome,*[6] which has an entire or toothed margin, according to the species. The teeth are arranged in one or two rows, and are either four in number, or a multiple of four. A peristome, magnified, is represented in Fig. 1, Gr. xxvii.

The term *theca*[7] is often applied to the united sporangium and calyptra, but is better to use the term sporangium for the entire vessel, as we have done, since it is then uniform with the term as applied to other flowerless plants.

Spores.—The spores are not attached to the spo-

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[1] L., *columella,* a little column. [2] Gr., *apophuo,* to spring from. [3] L., *dimidius,* through the middle. [4] L., *mitriformis,* mitre-shaped. [5] L., *operculum,* a cover. [6] Gr., *peri,* around; *stoma,* a mouth [7] Gr. theca, a vessel.

rangium, except in one or two instances. In the division known as *scale-mosses* or *liverworts*, thread-like appendages called *elaters*[1] are present among the spores.

The spores are produced from the mother-cell in fours, and as the whole of the cell is not absorbed, they are not free, but united in fours. This number is occasionally exceeded.

Method of Reproduction.—When the spores begin to germinate they develop branching threads, which unite together, forming a belted mass called the *protonema.*[2] The protonema is usually composed of the threads of many spores. The cells of which the threads are made up contain chlorophyll, which at once distinguishes them from similar structures in the fungi, to be presently described.

After a little time a swelling takes place upon the threads, from which a leafy shoot arises, which may be annual or of longer duration.

Archægonia and antheridia are next produced at different points, according to the habit of the species.

The antheridia, when ripe, discharge their fluid contents, and the spermatozoids, coming in contact with the embryo-cell of the archægonia, complete the act of fertilization.

Cell formation now takes place by division of the embryo-cell, and after a time a perfect sporangium is produced.

The archægonium increases at the same time, but as the sporangium develops its stalk, the archægonium is forced from its connection with the stem and carried upwards, eventually becoming the calyptra.

Secondary Modes of Reproduction.—Mosses possess another mode of reproduction analogous to the buds produced on the leaves of ferns. Upon the ends of the veins of the leaves, or among the roots, little bud-

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[1] *Gr., elater,* an impeller. [2] Gr., *protos*, first; *nema*, a thread.

like bodies are produced which are termed *gemmules*,[1] and are capable of developing perfect plants.

This method of reproduction is perhaps the only one in which some species propagate in this country, for they are never seen in fruit.

The *scale-mosses*, of which mention has been made, are distinguished from the other mosses, known as *urn-mosses*, by the sporangia being valvate; by the presence of elaters among the spores; by the rapid growth and decay of the fruits, and by the scale-like expansion of the leaves, which are sometimes of two kinds, alternating with each other, and suggesting the idea of leaves and stipules.

CHAPTER XXVII.

FUNGI.

Description.—The fungi constitute a class of plants which differ in some respects widely from all other forms of vegetable life. They are, for instance, incapable of taking nutriment from the mineral world directly, and hence only live upon organic matter.

Again, unlike other plants, they absorb oxygen and liberate carbonic acid.

They are also more highly nitrogenous than other plants.

We are familiar with fungi under the names of *mushrooms* and toadstools. Less familiar forms are found in *mould*, *rust*, *mildew*, *smut*, and the plants which produce the potato disease. The part we generally recognise as the fungus is really the fructification of the plant.

Mycelium.—The vegetative portion of the fungus is

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[1] L., *gemmula*, a little bud.

a thread-like filament or tough membrane, numbers of which combine and form a tangled mass, known as the *mycelium*,[1] or more familiarly as the *spawn*. The mycelium is either concealed beneath, or exposed upon, the surface of the substance upon which it vegetates, which is always of an organic character, generally decaying, but sometimes actually living tissue.

The mycelium is the vegetative condition of fungi, and it sometimes grows for a length of time without producing any fructification.

Reproductive Organs and their Development.—When the mycelium has become sufficiently developed, and the atmospheric and other conditions are favourable, the fructification makes its appearance and grows with great rapidity.

If we regard the mushroom *(agaricus)* as a typical fungus, we find that from various parts of the mycelium small round knobs make their appearance. As they continue to grow upwards they are seen to be supported upon a stalk, which is termed the *stipe*.

The knob expands and forms a cup, called the *pileus*,[2] which is the head of the mushroom.

During the expansion of the pileus, the margin in contact with the stipe becomes ruptured and breaks away from it, leaving a ring, or *annulus*,[3] round the stipe, showing the line of attachment.

The under surface of the pileus consists of a number of plates or gills, called *lamellæ*,[4] which radiate from the stipe.

These lamellæ are covered with a membrane, called the *hymenium*,[5] which bears the spores, or reproductive organs.

The spores are borne in simple or branched processes

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[1] Gr., *mukes*, a fungus. [2] L., *pileus*, a cap. [3] L., *annulus*, a little ring. [4] L., *lamella*, a plate. [5] Gr., *hymen*, a membrane.

termed *sporophores*[1] or *basidia*,[2] and are usually aggregated in fours.

Acrosporous Fruits.—The true fruit of fungi are formed on two separate plans. In the first the tips of certain cellular threads of the reproductive mass swell into little bodies surmounted by *spicules*,[3] each of which gradually develops a single cell. The endochrome of this cell is condensed into a single mass, or becomes compound by the formation of membranous partitions. The spores so formed fall off eventually. This mode of fructification is termed *acrosporous*,[4] and is prevalent among the higher fungi.

Ascogerous Fruits.—In the second case, as before, special threads swell, but form bags or tubes, the cell-contents of which are resolved after a time into a mass of spores. The number of spores is usually eight, or a multiple of that number.

This mode of fructification is termed *ascogerous*.[5]

Secondary mode of Reproduction.—There is a secondary mode of fructification observed among fungi. Here, again, cells separate from the tips of certain threads. They are termed *conidia*,[6] and have been observed in most groups of fungi.

Spermatia, similar to the spermatozoids of algæ, have been discovered in some few species. But as the study of these plants is rapidly increasing, fresh instances are continually brought to light.

They may be readily observed in the *æcidium*[7] which grows upon *euphorbia*, and more sparingly upon the æcidium of *ficaria*.

The lowest form of fungi are found in such as develop their mycelium in fluid, such as the *yeast-plant*.

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[1] Gr., *spora*, and *phoreo*, to bear. [2] Gr., *basis*, a base. [3] L., *spicula*, a little spike. [4] Gr., *acros*, the summit; *spora*. [5] Gr., *askos*, a bag; *gero*, to bear. [6] Gr., *konis*, dust. [7] A microscopic fungus, known as a *cluster-cup*.

When this plant is developed out of a fluid, however, it gives use to a fructification of a much more complicated character than the mycelium, by which it is generally known.

Economic Value.—The members of this class are generally regarded with aversion and suspicion. Many of them certainly commit great ravages among other plants that are useful to man. Of these the *borytis*, that attacks the potato, and the *rust*, which destroys wheat, are some of the greatest pests in nature.

On the other hand many of them are excellent and nutritious articles of food. The great drawback to the more general use of fungi as articles of diet is the uncertainty as to the influence they will have upon the system at different times.

CHAPTER XXVIII.

LICHENS.

Description of Lichens.—These plants form a distinct group of a class called *thallogens*,[1] in which there is no distinction between axis and appendages. The more conspicuous examples appear as a tough, leafy expansion of an irregular form, called the *thallus*, having root-like appendages of a filiform character, which penetrate into the soil in those species which live upon the ground. On their upper surface are borne cup-shaped bodies filled with membranous sacs containing spores. On some lichens other receptacles are found containing reproductive organs of another kind. A third means of reproduction is afforded by certain chains of cells containing chlorophyll.

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[1] *Gr., thallus*, a receptacle; *genao*, to produce.

Lichens are found universally in light, exposed situations, and, though requiring moisture occasionally, they can withstand drought for a length of time, that would be fatal to any other kind of vegetation. They are found on the hardest rocks, on exposed stones, old walls, bark of trees, park palings, wooden buildings, on the ground—no matter what may be the nature of the soil—near the sea-shore, as well as far inland.

They are mostly of slow growth, and live for a very long period. Their forms are extremely diverse, some being wart-like, others like cups, clubs, shields, &c.; some are bearded, others covered with lines and dots, like a map; others again with forms like written characters. In colour they are as varied as in shape, some being extremely rich in hue, while others resemble old leather in tint and texture.

Though lichens require no soil for their nourishment, yet by their decay they form the first traces of soil which serves to support the life of higher orders of vegetation. They, in fact, reduce the hard, sterile rock to rich soil, and are thus the pioneers of vegetation.

Lichens are of little use as food plants. A few of them furnish a kind of starch, and some are used medicinally in the form of mucilage, to give relief in pulmonary[1] complaints.

Several afford valuable dyes, many tons being used annually for that purpose.

Apothecia.—The apothecia[2] are the cup-shaped bodies above-mentioned. They contain menbranous sacs called *asci*,[3] which are filled with aggregations of spores, termed *sporidia*.[4]

When the apothecia are open the lichens are said to

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[1] Diseases of the chest. [2] Gr. *apotheke*, a repository. [3] Gr., *askos*, a bag. [4] Gr., *spora*, a seed; eidos, like.

be *gymnocarpous*,[1] when they are closed *angiocarpous*. These characters are used to separate the lichens into two primary divisions.

Gymnocarpous Lichens.—In this section each apothecium consists of a more or less flattened disc, called the *thalamium*,[3] which contains the spores, and an envelope which surrounds and protects the thalamium, called the *excipulum*.[4] The excipulum may be of the same nature as the thallus, or it may differ in colour, and texture, or even be absent altogether.

Angiocarpous Lichens.—In this section the excipulum encloses the thalamium as a globular envelope, from which the spores issue when ripe by means of a little pore, called the *osteolum*.[5] The excipulum in angiocarpous lichens is generally called the *perithecium*.[6]

Thalamium.—The thalamium is a collection of elongated and densely packed cells, called *asci*, cemented by a very tenacious mucus, which sometimes renders their separation a matter of difficulty. The small and somewhat irregular cells which support the asci and form the base of the thalamium, constitute what is known as the *hypothecium*.[7]

Paraphyses mixed with the asci are found cellular bodies destitute of spores or sporidia, which are termed *paraphysès*.[8] They are longer than the asci, and are mostly club-shaped. They are composed of six or eight cells, of which the terminal one is largest, and is moreover coloured. The cells contain mucus. Paraphyses precede the asci in the order of their development, and very probably serve as reservoirs of nutriment to them.

Picnidia.—The picnidia[9] form the second series of reproductive organs mentioned above. They are com-

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[1] Gr., *gymnos*, naked; *karpos*, fruit. [2] Gr., *aggios*, a vessel. [3] Gr., *thalamus*, a bed. [4] L., *excipio*, to receive. [5] L., *osteolum*, a little mouth. [6] Gr., *peri*, around; *theke*, a sac. [7] Gr. *hypo*, beneath, *theke*. [8] Gr., *paraphysis*, an offset. [9] Gr., *piknites*, denseness.

paratively of rare occurrence, and appear as dark spots upon the thallus, and support upon short stalks elongated, colourless bodies, called *stylospores*,[1] which contain granular matter. Their function is as yet unknown, but they are conjectured to be of a reproductive character.

Gonidia.—A secondary system of reproductive bodies exist as a layer of loosely aggregated cells containing chlorophyll, situated beneath the outer layer of the thallus. The cells are termed gonidia,[2] and they are liberated by the breaking up of the surface of the thallus, and produce perfect plants. They perhaps find their analogues in the gemmules of mosses, and the buds produced on the fronds of ferns.

When conditions are unfavourable for the perfection of true fruit, lichens are often propagated by this means alone.

Spermagones.—Other organs, called spermagones,[3] are found scattered about in the perithecia, or embedded in the thallus. They appear as little black specs, and contain elliptical, or curved bodies, called *spermatia*, which are supposed to fertilize the spores. In this case the spermagones may be likened to the antheridia of mosses and ferns, and the spermatia to the spermatozoids; but this is a matter which further research can alone decide.

CHAPTER XXIX.

ALGÆ.

Description.—Under the popular name of seaweeds we recognise a large group of thallogens having a close affinity with the class *lichenes* in everything but habit.

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[1] Gr. *stylos*, a stalk, and *spora*. [2] Gr., *gone*, generation.
[3] Gr., *sperma*, seed; *gone*.

Though popularly called seaweeds, numbers of them live only in fresh water.

In this class some of the most simple and minute plants in the vegetable kingdom are to be met with, microscopic in size, unicellular in structure, varied in form, and of exceeding beauty. On the other hand, many of them are of gigantic proportion, rivalling in length the largest forest-trees, and some of them are of considerable substance.

Algals are distinguished as cellular, flowerless plants; without true roots; living, with rare exceptions, entirely under water, and imbibing their nutriment by their whole surface from the medium in which they grow.

Some few are parasitic upon others.

They are propagated by spores.

Endochrome.—The colouring matter contained in the cells of algæ is called *endochrome.*[1] It differs from chlorophyll in being variously coloured, instead of always green. The colours of the spores are used in separating these plants into distinct orders; thus we have an order in which the spores are *olive*, one in which they are *red*, and a third in which they are *green.*

Frond.—The branching expansions of these plants are called fronds. They must not be confounded with the fronds of ferns, for, instead of being appendages to the axis, they are part of the general tissue, and there is no distinction in structure or function between the parts. Fronds of algæ are therefore mere branch-like expansions of the thallus.

Reproductive Organs.—The reproductive organs of algæ are of several kinds, the two principal being the *capsular* and *granular* fruits. These seem to be capable of mutually fertilizing each other, though each can of itself produce perfect plants. They contain

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[1] Gr., *endon*, inner; *chroma*, colour.

agglomerations of spores which are fertilized by spermatozoids borne in antheridia. There are other bodies developed, called *nemathecia*,[1] whose function is unknown.

Capsular Fruit.—These capsules vary greatly in form in the different species, and to the more marked varieties names are given. The term *ceramidium*[2] is commonly used to denote a capsule of a more or less globular form, and might with advantage be used to denote the whole of these fruits. The capsules contain agglomerations of spores.

Granular Fruit.—These organs are contained in the joints of special threads, and are either naked or contained in a membranous sac, called a *conceptacle*.[3] They consist of spores, or rather *tetraspores*,[4] for they are divided into four sections. This arises from division of the endochrome. The four sections are arranged in a pyramidal form, or where only three can be seen at once under the microscope at one time.

Antheridia.—The antheridia contain spermatozoids of a peculiar character. The peculiar bodies are furnished with one or more whip-like appendages, and after liberation from the antheridia, move about in the water with great activity for a considerable time. Some of them eventually come in contact with the spores which they fecundate, and give rise to new plants.

These are reproductive organs, possessing threads or cilia, and having the power to fertilize the spores. They are similar in shape to spermatozoids.

Nemathecia.—These bodies appear as wart-like excrescences, composed of filaments having the appearance of a string of beads. Their function is unknown.

Mode of Reproduction.—The granular and capsular

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[1] Gr., *nema*, a thread. [2] Gr., *keramos*, a little vessel.
[3] L., *conceptaculum*, a small vessel. [4] Gr., *tetra*, four.

fruits arise from the division of the endochrome of a cell, or from the union of the endochromes of two cells. The spores appear to be fecundated by the spermatozoids, somewhat after the manner of the *lichens*.

Classification.—The algæ are divided into three orders, distinguished by the colour of the spores. They are—1. *Melanospermæ*,[1] spores olive; 2. *Rhodospermæ*,[2] spores red; 3. *Chlorospermæ*,[3] spores green.

1. *Melanospermæ*.—Colour, olive green, sometimes inclining to brown. Different forms of fructification present on the same or on separate individuals. Spores, olive coloured, naked or contained in conceptacles. Antheridia, often resembling conceptacles, filled with active spermatozoids.

2. *Rhodospermæ*.—Colour, rose-red or purple, rarely inclining to brown or green. Fruit of two kinds. First, spores contained in conceptacles, or tetraspores generally immersed in the frond, and rarely contained in conceptacles. The conceptacles arise from a cell whose endochrome is quadripartite, and ultimately divides into four distinct bodies. Antheridia filled with active spermatozoids, and often on distinct plants.

3. *Chlorospermæ*.—For the most part bright green, but varying occasionally to purple or olive. "Extremely various in form and appearance, often filiform, propagated by the simple division of the endochrome, by the transformation of particular joints, or by the metamorphosis of the endochrome into zoospores." (*Berkley*). Spermatozoids rare.

Distribution.—Certain species of algæ are confined to particular depths of the sea. Thus many of the melanospermæ are confined to the tide-range, and are alternately submerged and exposed. Rhodospermæ generally affect a greater depth, and are consequently

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[1] Gr., *melanos*, black; *sperma*, seed. [2] Gr., *rhodos*, red. [3] *chloros*, green.

further removed from the coast-line. Some of the chlorosperms, which live in deep water, rise to the surface under the influence of light, and sink when darkness comes on.

Economic Value.—The algæ are of little commercial interest, being now chiefly valuable for the iodine they contain. Formerly large quantities were burnt for the sake of the soda they contain, which was used in the manufacture of soap. The seaweed was called *kelp*. Soda is more abundantly and cheaply produced in other ways now.

Chondrus crispus, or *Carrageen moss*, is still used medicinally for the sake of its mucilage, which is of the nature of starch or sugar.

Some of the African algæ have recently been made into knife handles and similar articles, but they have not taken a place among the established manufactures, and must hence be considered as curiosities. The material closely resembles stag's-horn.

APPENDIX.

TABLE OF ECONOMIC PRODUCTS.

FOOD PRODUCTS.

Common Name.	Botanical Name.	Natural Order.	Country.	Part used.
Apple	*Pyrus malus*	*Rosaceæ*	Europe	Fruit.
Apricot	*Prunus Armeniaca*	*Rosaceæ*	Europe	Fruit.
Almond	*Amygdalus communis*	*Rosaceæ*	South Europe	Fruit.
Arrowroot	*Maranta arundinacea*	*Marantaceæ*	West Indies	Root.
Arrowroot	*Curcuma angustifolia*	*Zingiberaceæ*	East Indies	Root.
Arrowroot	*Manhiot utilissima*	*Euphorbiaceæ*	Brazil	Root.
Banana	*Musa sapientum*	*Musaceæ*	Tropics	Fruit.
Barley	*Hordeum* (several varieties)	*Graminaceæ*	Europe	Fruit.
Brazil Nut	*Bertholletia excelsa*	*Myrtaceæ*	Brazil	Seed.
Bean	*Phaseolus vulgaris*	*Leguminosæ*	Europe and Egypt, &c.	Seed.
Beet	*Beta vulgaris*	*Chenopodiaceæ*	France, &c.	Root.

FOOD PRODUCTS—(Continued).

Common Name.	Botanical Name.	Natural Order.	Country.	Part use
Buckwheat	*Fagopyrum esculentum*	*Polygonaceæ*	Europe and N. America	Seed.
Chesnut	*Castanea vesca*	*Corylaceæ*	Spain	Fruit.
Chicory	*Cichorium Intybus* ..	*Compositæ*	Europe	Root.
Cocoa	*Theobroma cacao*	*Byttneriaceæ*	West Indies & Tropical America..	Seed.
Coco-nut ..	*Cocos nucifera*	*Palmaceæ*	Tropics	Seed.
Coffee	*Coffea Arabica*	*Cinchonaceæ* ..	Tropics	Seed.
Currants	*Vitis vinifera (var.).*	*Vitaceæ*	Greece	Fruit.
Dates	*Phœnix dactylifera* ..	*Palmaceæ*	Africa........	Fruit.
Filberts	*Corylus avellana*	*Corylaceæ*	England......	Seed.
Gooseberries.	*Ribes grossularia*....	*Grossulariæ* ..	England......	Fruit.
Grapes	*Vitis vinifera*	*Vitaceæ*	S. Europe	Fruit.
Guinea, or Negro Corn	*Andropogon sorghum*	*Graminaceæ*	E. and W. Indies and Africa....	Seed.
IndianCorn or Maize	*Zea mays*	*Graminaceæ*	Europe, Asia, Africa and America ..	Seed.
Lemon	*Citrus limonium*...	*Aurantiaceæ* ..	S. Europe	Fruit.
Lentils	*Ervum lens*	*Leguminosæ* ..	France	Seed.
Millet	*Setaria Italica*	*Graminaceæ* ..	India	Seed.
Oats	*Avena sativa*	*Graminaceæ* ..	Europe	Seed.
Orange, sweet	*Citrus aurantium* ..	*Aurantiaceæ.*	S. Europe, India, China, &c.	Fruit.
Orange, bitter	*Citrus vulgaris*......	*Aurantiaceæ* ..	Spain	Fruit.
Olives	*Olea Europæa*	*Oleaceæ*	S. Europe	Fruit.
Onions	*Allium cepa*	*Liliaceæ*......	Europe	Bulb.
Pear	*Pyrus communis*	*Rosaceæ*	Europe	Fruit.
Peas	*Pisum sativum*......	*Leguminosæ* ..	Europe	Seed.
Pine Apple..	*Ananassa sativa*	*Bromeliaceæ*	E. and W. Indies....	Fruit.
Pomegranate	*Punica granatum* ..	*Myrtaceæ* ..	S. Europe & Persia....	Fruit.
Potato	*Solanum tuberosum*..	*Solanaceæ* ..	Europe and America..	Tuber.
Prune	*Prunus domesticus* ..	*Rosaceæ*	France	Fruit.
Rice	*Oryza*	*Graminaceæ*	Europe, Asia, Africa and America..	Seed.
Rye	*Secale cereale*........	*Graminaceæ* ..	Europe	Seed.
Sago	*Sagus Rumphii*......	*Palmaceæ*	Singapore, &c.	Stem.
Sugar(cane)	*Saccharum officinarum*	*Graminaceæ*	E. and W. Indies, &c.	Stem.
Sugar (maple)	*Acer saccharum*	*Aceraceæ*	N. America ..	Sap.
Tapioca	*Manihot utilissima*..	*Euphorbiaceæ*	Brazil........	Root.
Tea	*Thea viridis, &c.* ..	*Ternströmiaceæ*	China, &c.....	Leaf.
Walnut......	*Juglans regia*	*Juglandaceæ*..	Europe	Seed.
Wheat	*Triticum vulgaris, &c.*	*Graminaceæ*	Europe, N. America, Australia, &c.	Seed.

SPICES.

Common Name.	Botanical Name.	Natural Order.	Country.	Part used.
Allspice, or Pimento	*Eugenia pimento*	*Myrtaceæ*	W. Indies	Fruit.
Anise	*Pimpinella anisum* ..	*Umbelliferæ*	S. Europe & E. Indies	Fruit.
Caper	*Capparis spinosa*	*Capparidaceæ*.	Sicily, &c.....	Flower.
Capsicum, or chilli	*Capsicum annuum* ..	*Solanaceæ*	E. Indies	Fruit.
Carawayseeds	*Carum carui*........	*Umbelliferæ*	Holland and Germany	Fruit.
Cinnamon	*Cinnamomum zeylanicum*	*Lauraceæ*	Ceylon	Bark.
Clove	*Caryophyllus aromaticus*	*Myrtaceæ* ..	E. and W. Indies and Mauritius	Flower Bud.
Clove bark	*Dicypellium caryophyllatum*	*Lauraceæ*	Brazil	Bark.
Ginger	*Zingiber officinale* ..	*Zingiberaceæ*	E. and W. Indies....	Rhizome.
Mustard	*Sinapis alba*	*Cruciferæ* ..	N. Europe & E. Indies	Seed.
Nutmeg	*Myristicaceæ moschata*	*Myristiaceæ*.	E. and W. Indies....	Seed.
Vanilla......	*Vanilla aromatica* ..	*Orchidaceæ* ..	W. Indies	Fruit.

TEXTILE FABRICS.

Common Name.	Botanical Name.	Natural Order.	Country.	Part used.
Bast	*Tilia Europea*	*Tiliaceæ*......	Russia	Bark.
China grass..	*Bœhmeria nivea*	*Urticaceæ*	China & India	Bark.
Coir, or Coco-nut fibre	*Cocos nucifera*......	*Palmaceæ*	India, &c.. ..	Fruit.
Cotton-wool	*Gossypium (several varieties)*	*Malvaceæ* ..	America, India, &c. ..	Woolly covering of Seed.
Flax	*Linum usitatissimum*	*Linaceæ*....	Ireland, Holland and Russia ..	Stem.
Hemp	*Cannabis sativa*	*Urticaceæ* ..	Europe, N. America and Africa	Stem.
Jute	*Corchorus capsularis*	*Tiliaceæ*	India	Bark.
Manilla hemp, or plantain fibre	*Musa textalis*	*Musaceæ*	India	LeafStalk
Mexican fibre	*Agave Americana* ..	*Liliaceæ*......	America......	Leaf.
Monkey, or Para grass	*Attalea funifera*	*Palmaceæ*	Brazil	LeafStalk
Phormium, or New Zealand flax	*Phormium tenax*	*Liliaceæ*......	New Zealand..	Leaf.
Rattans	*Calamus rotang*	*Palmaceæ*	EasternForests	Stem.
Vegetablesilk	*Chorisia speciosa*....	*Sterculiaceæ* ..	S. America ..	Covering of seed.

DYES.

Common Name.	Botanical Name.	Natural Order.	Country.	Part used.
Alkanet root	*Anchusa tinctoria* ..	*Boraginaceæ* ..	S. Europe	Root.
Anatto	*Bixa orellana*	*Flacourtiaceæ*	E. and W. Indies and S. America	Seed.
Brazil wood	*Cæsalpinia crista*....	*Leguminosæ* ..	Brazil........	Wood.
Braziletto	*Cæsalpinia Braziliensis*	*Leguminosæ* ..	Spain	Wood.
Bookum, Bukkum, or Sapan wood	*Cæsalpinia Sapan* ..	*Leguminosæ* ..	E. Indies	Wood.
Camwood ..	*Baphia nitida*	*Leguminosæ* ..	Sierra Leone..	Wood.
Cudbear	*Lecanora*	*Lichenæ*	Europe	Whole Plant.
Dragon's blood ..	*Calamus draco*......	*Palmaceæ*	E. Indies	Fruit.
Ebony (green)	*Jacaranda ovalifolia*	*Bignoniaceæ* ..	S. America ..	Wood.
Fustic (old)..	*Maclura tinctoria* ..	*Urticaceæ* ..	W. Indies & S. America	Wood.
Fustic (young)	*Rhus cotinus*......	*Anacardiaceæ*	Greece	Wood.
Gamboge..	*Hebradendron Cambogioides*	*Clusiaceæ*	Ceylon	Exudation from young Wood.
Indigo	*Indigofera tinctoria* .	*Leguminosæ* ..	India	Leaf and Stem.
Lima, Nicaragua, or Peach wood	*Cæsalpinia echinata* .	*Leguminosæ* ..	Peru, &c.	Wood.
Logwood ..	*Hæmatoxylon Campechianum*......	*Leguminosæ*.	Central America..	Wood.
Madder	*Rubia tinctoria*	*Galiaceæ*......	Europe	Root.
Munjeet	*Rubia munjista*	*Galiaceæ*......	India & Japan	Root.
Orchella weed, Orchil, or Archil....	*Rocella fuciformis* ..	*Licheneæ* ..	Angola and Lima, &c.	Whole Plant.
Quercitron ..	*Quercus tinctoria*....	*Corylaceæ*	N. America ..	Bark.
Safflower	*Carthamnus tinctorius*	*Compositæ*	E. Indies	Petals.
Saffron	*Crocus sativus*	*Iridaceæ*......	France & Spain	Stigmas.
Saunders, or Red Sandal wood..	*Pterocarpus Santalinus*	*Leguminosæ* ..	India	Wood.
Tisso........	*Butea frondosa*......	*Leguminosæ* ..	E. Indies	Flower.
Turmeric....	*Curcuma longa*......	*Zingiberaceæ*..	Asia	Rhizome.
Woad	*Isatis tinctoria*......	*Cruciferæ*	Europe	Stem and Leaf.
Yellowberries	*Rhamnus infectorius*	*Rhamnaceæ* ..	Smyrna	Berries.

TANNING MATERIALS.

Common Name.	Botanical Name.	Natural Order.	Country.	Part used.
Acacia	*Acacia melanoxylon.*	*Leguminosæ*	Barbary and Australia ..	Bark.
Cork	*Quercus suber*	*Corylaceæ*	Europe	Bark.
Catechu	*Acacia catechu*	*Leguminosæ* ..	India	Extract from the Wood.
Catechu	*Areca catechu*	*Palmaceæ*	India	Seed.
Catechu	*Nauclea Gambir*	*Cinchonaceæ* ..	India	Leaf.
Divi-divi, Libi-libi, or Libi-divi	*Cæsalpinia coriaria* .	*Leguminosæ*	Central America & W. Indies	Seed Pod.
Mangrove ..	*Rhizopora Mangle* .	*Rhizophoraceæ*	West Indies and Africa	Bark.
Myrobalans ..	*Terminalia chebula* .	*Combretaceæ* ..	India	Seed.
Oak	*Quercus pedunculata*	*Corylaceæ*	Europe	Bark.
Pomegranate	*Punica granatum* ..	*Myrtaceæ*	Barbary	Rind of Fruit.
Valonia	*Quercus Ægilops*	*Corylaceæ*	Levant	Acorn Cups.

GUMS, RESINS, ETC.

Arabic	*Acacia Arabica*	*Leguminosæ*	Barbary and Turkey ..	Exudation from Stem.
Benzoin	*Styrax benzoin*	*Styraceæ*	E. Indies	"
Canada balsam	*Abies balsamea*	*Coniferæ*	N. America ..	"
Copal	*Trachylobium mariantum*	*Leguminosæ* ..	Brazil	"
Copal	*Hymenæa*	*Leguminosæ* ..	Africa	"
Copal	*Hymenæa Courbaril* .	*Leguminosæ* ..	E. Indies	"
Copal	*Damara Australis* ..	*Coniferæ*	Australia	"
Dragon gum, or tragacanth	*Astragalus gummifer*	*Leguminosæ* ..	Asia Minor ..	"
Frankincense	*Abies excelsa*	*Coniferæ*	N. America ..	"
Gutta percha	*Isonandra gutta*	*Sapotaceæ*	Malay Islands	"
India rubber	*Ficus elastica*	*Moraceæ*	India	"
India rubber	*Siphonia elastica*	*Euphorbiaceæ*	Brazil	"
Juniper gum	*Callitris quadrivalvis*	*Coniferæ* ..	Barbary and Turkey ..	"
Kuteera	*Sterculia urens*	*Sterculiaceæ* ..	Coromandel ..	"
Mastic	*Pistacia lentiscus* ..	*Anacardiaceæ*	S. Europe & N. Africa ..	"
Pitch (distillation from tar)	*Pinus sylvestris*	*Coniferæ* ..	Europe, N. America, &c.	"
Tar	*Pinus sylvestris*	*Coniferæ* ..	Europe, N. America, &c.	"
Turpentine ..	*Pinus palustris*	*Coniferæ* ..	Europe, N. America, &c.	"

OILS, ETC.

Common Name.	Botanical Name.	Natural Order.	Country.	Part used
Almond oil ..	*Amygdalus communis*	*Rosaceæ*	Europe	Seed.
Aniseed oil ..	*Pimpinella anisum* ..	*Umbelliferæ*	E. Indies & Germany .	Seed.
Bergamot ..	*Citrus bergamia*	*Aurantiaceæ* ..	Sicily	Rind of Fruit.
Cassia oil ..	*Cinnamomum zeylanicum*	*Lauraceæ*	China	Bark.
Cinnamon oil.	,, ,,	*Lauraceæ*	China	Bark.
Coco-nut ,,	*Cocos nucifera*	*Palmaceæ* ..	Manilla and Ceylon ..	Nut.
Cotton seed oil	*Gossypium herbaceum*	*Malvaceæ*	United States	Seed.
Ground nut oil	*Arachis hypogæa*	*Leguminosæ* ..	Africa........	Seed.
Lavender oil	*Lavendula spica* ..	*Labiateæ* ..	France and Germany .	Flower & leaf.
Linseed oil ..	*Linum usitatissimum*	*Linaceæ*	E. Indies & Russia ..	Seed.
Lemon, essence of	*Citrus limonum*	*Aurantiaceæ* ..	S. Europe ..	Rind of Fruit.
Myrtle wax ..	*Myrica cerifera*	*Myricaceæ*	United States	Berry.
Mustard-seed oil ..	*Sinapis glauca*	*Cruciferæ*	E. Indies	Seed.
Niger seed oil	*Verbesina sativa*	*Compositæ*	India	Seed.
Olive oil	*Olea Europea*	*Oleaceæ*	Spain	Fruit.
Otto of roses	*Rosa sp.*	*Rosaceæ*	Smyrna	Petals.
Palm oil	*Elias Guineensis*	*Palmaceæ*	W. Africa	Fruit.
Peppermint	*Mentha piperita*	*Labiateæ* ..	Germany & the United States....	Leaf.
Poppy seed oil	*Papaver somniferum*	*Papaveraceæ* ..	India, &c.	Seed.
Rape oil	*Brassica napis*	*Cruciferæ*	India	Seed.
Rosemary ..	*Rosmarinus officinalis*	*Labiateæ*	England......	Leaf.
Seed oil	*Jatropha curcas*	*Euphorbiaceæ* .	Lisbon	Seed.
Vegetable wax	*Corypha cerifera*	*Palmaceæ*	S. America ..	Leaf.

MEDICINE.

Aloes	*Aloe vulgaris, etc.* ..	*Liliaceæ*	W. Indies	Leaf.
Ammoniacum, gum	*Dorema ammoniacum*	*Umbelliferæ* ..	Persia......	From Stem.
Asafœtida, gum	*Ferula asafœtida*	*Umbelliferæ* ..	Persia........	Root.
Cardamons	*Elettaria cardamomum*	*Zingiberaceæ* .	Malabar Coast	Capsule.
Castor oil ..	*Ricinus communis* ..	*Euphorbiaceæ*.	Africa........	Seed.
Camphor	*Camphora officinarum*	*Lauraceæ*	China, Batavia	Wood.
Camphor ..	*Dryobalanops camphora*	*Dipterocarpaceæ*	Sumatra......	Stem.
Galbanum, gum	*Galbanum officinale*..	*Umbelliferæ* ..	Persia......	Exudation from Stalk.

MEDICINE—(Continued).

Common Name.	Botanical Name.	Natural Order.	Country.	Part used.
Iceland moss	*Cetraria islandica* ..	*Lichenæ*	Europe	Whole Plant.
Jalap	*Exogonium purga* ..	*Convolvulaceæ*	Mexico	Tuber.
Liquorice ..	*Glycyrrhiza glabra* ..	*Leguminosæ* ..	Italy	Root.
Myrrh, gum	*Balsamodendron Myrrha*	*Amyridaceæ*	E. Indies & Turkey ..	Exudation from Stem.
Manna	*Ornus Europea*	*Oleaceæ*	Sicily	"
Nux vomica.	*Strychnos nux vomica*	*Apocynaceæ*.	E. Indies & Turkey ..	Root.
Opium	*Papaver somniferum*	*Papaveraceæ*	E. Indies & Turkey ..	Unripe Capsules.
Peruvian bark	*Cinchona (several varieties)*	*Cinchonaceæ* ..	Peru & India..	Bark.
Reinder moss	*Cladonia rangiferina*	*Lichenæ*	Europe	Whole Plant.
Rhubarb ..	*Rheum (several varieties)*	*Polygonaceæ*	East Indies & Turkey	Root.
Senna	*Cassia obovata*	*Leguminosæ*	S. Europe & W. Indies.	Leaf.

WOODS.

Alder	*Alnus glutinosa*	*Amentiferæ* ..	Europe	Stem.
Ash	*Fraxinus excelsior* ..	*Oleaceæ*	Europe	"
Beech	*Fagus sylvatica*	*Amentiferæ* ..	Europe	"
Blue gum ...	*Eucalyptus piperita*.	*Myrtaceæ*	Australia	"
Birch	*Betula (several varieties)*	*Betulaceæ* ..	Europe and America..	"
Botany Bay oak, or beef wood	*Casuarina tortulosa*	*Casuarinaceæ*	Australia	"
Box	*Buxus Balearica*	*Euphorbiaceæ*	Europe	"
Bully	*Achras sapota*	*Sapotaceæ*	Cuba	"
Camphor	*Laurus camphora*....	*Lauraceæ*	China	"
Cedar	*Cedrela odorata*	*Cedrelaceæ* ..	America and W. Indies	"
Courie pine..	*Damara Australis* ..	*Coniferæ*	New Zealand	"
Deal	*Pinus sylvestris*......	*Coniferæ* ..	Europe and America..	"
Ebony (black)	*Diospyrus ebenus*	*Ebenaceæ*	Mauritius	"
Ebony	*Dispyrus melanoxylon*	*Ebenaceæ*	Asia	"
Ebony, East India, or blackwood	*Dalbergia latifolia* ..	*Leguminosæ* ..	E. Indies	"
Elm	*Ulmus campestris*	*Ulmaceæ*	Europe	"
Fir..........	*Abies excelsa*.... ...	*Coniferæ*	Europe	"
Greenheart ..	*Nectandra Rodiæi* ..	*Lauraceæ*	Demerara	"
Holly	*Ilex aquifolium*	*Aquifoliaceæ*	Europe	"
Iron wood ..	*Metrosideros vera*....	*Myrtaceæ*	China........	"
Jack wood	*Artocarpus integrifolia*	*Artocarpaceæ*	Asia	"
Lance wood .	*Duguetia quitarensis*	*Anonaceæ*	Guiana	"
Lignum vitæ	*Guaiacum officinale*..	*Zygophyllaceæ*	Jamaica......	"
Lime........	*Tilia Europea*	*Tiliaceæ*	Europe	"

WOODS—(Continued).

Common Name.	Botanical Name.	Natural Order.	Country.	Part us
Locust wood	*Robinia pseudacacia*	*Leguminosæ*	Asia	Stem.
Maple	*Acer campestris*	*Aceraceæ*	Europe	"
Mora	*Mora excelsa*	*Leguminosæ*	Guiana	"
Mahogany	*Sweitenia mahogani*	*Cedrelaceæ*	Central America & Cuba	"
Oak (African, or African mahogany)	*Oldfieldia Africana*	*Euphorbiaceæ*	Africa	"
Oak (white)	*Quercus alba*	*Corylaceæ*	N. America	"
Oak (Baltic)	*Quercus pedunculata*	*Corylaceæ*	Europe	"
Oak (Adriatic)	*Quercus cerris*	*Corylaceæ*	Europe	"
Orange	*Citrus aurantium*	*Aurantiaceæ*	Europe	"
Olive	*Olea Europæa*	*Oleaceæ*	Europe	"
Partridge wood	*Heisteria coccinea*	*Oleaceæ*	W. Indies	"
Pine (white)	*Pinus strobus*	*Coniferæ*	United States	"
Porcupine wood	*Cocus nucifera*	*Palmaceæ*	Ceylon	"
Purple wood	*Copaiba pubiflora*	*Leguminosæ*	Guiana	"
Redgum	*Eucalyptus resinifera*	*Myrtaceæ*	Australia	"
Rose	*Triptolormœa (several varieties)*	*Leguminosæ*	Brazil	"
Sabicu	*Acacia formosa*	*Leguminosæ*	W. Indies	"
Satin	*Mata Guianensis*	*Ebenaceæ*	S. America	"
Satin	*Sweitenia chloroxylon*	*Cedrelaceæ*	Asia	"
Sandal	*Santalum album*	*Santalaceæ*	Asia	"
Snake wood	*Piratinera Guianensis*	*Artocapaceæ*	S. America	"
Teak	*Tectona grandis*	*Verbenaceæ*	Asia	"
Walnut	*Juglans regia*	*Juglandaceæ*	Russia and Germany	"
Willow	*Salix alba*	*Amentiferæ*	Europe	"
Yew	*Taxus baccata*	*Coniferæ*	Europe	"
Zebra wood	*Guettarda speciosa*	*Cinchonaceæ*	W. Indies	"

MISCELLANEOUS.

Areca nut	*Areca catechu*	*Palmaceæ*	India, &c.	Nut.
Carrageen, or Irish moss	*Chondrus crispus*	*Algæ*	N. Europe	Whole Plant
Ceylon moss	*Fucus spinosus*	*Algæ*	Ceylon	"
Calamus	*Acorus calamus*	*Acoraceæ*	Europe, Asia Africa and America	Seed.
Coquilla nut	*Attalea funifera*	*Palmaceæ*	S. America	Nut.
Cork	*Quercus suber*	*Corylaceæ*	Spain	Bark.
Juniper	*Juniperus*	*Coniferæ*	Germany & Holland	Berry.
Malacca cane	*Calamus Malacca*	*Palmaceæ*	China, &c.	Stem.
Rice paper	*Aralia papyrifera*	*Araliaceæ*	China	Pith.
Tobacco	*Nicotiana (several varieties)*	*Solanaceæ*	W. Indies & United States	Leaf.
Tonca beans	*Dipteryx odorata*	*Leguminosæ*	Guiana	Seed.
Vegetable ivory	*Phytelephas macrocarpa*	*Palmaceæ*	Peru	Seed.

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